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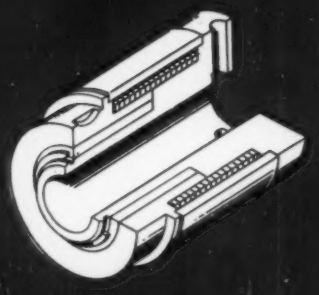
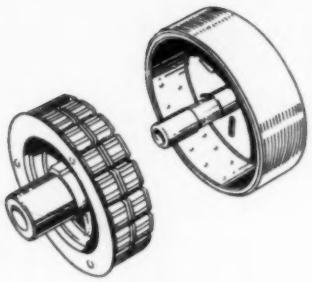
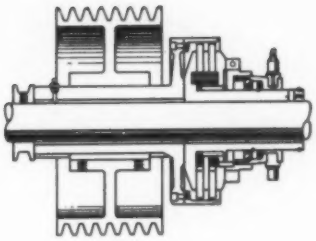
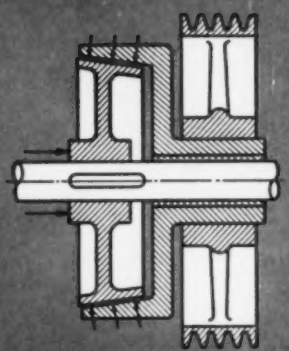
McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · JUNE 19, 1961









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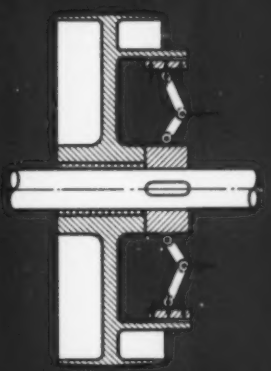

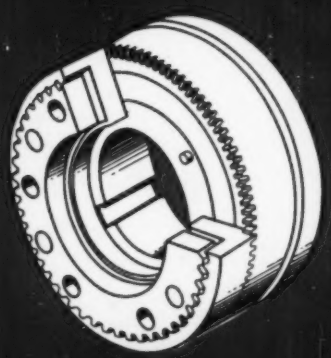

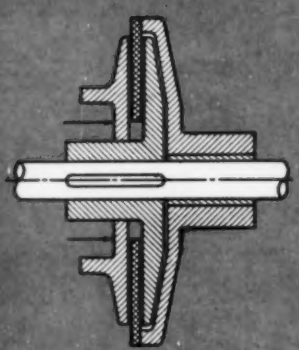

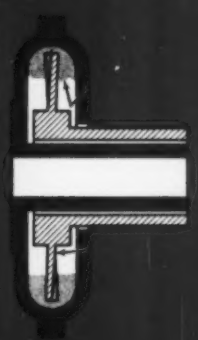

WHY WE NEED NONSTANDARD RATINGS FOR MOTORS . .
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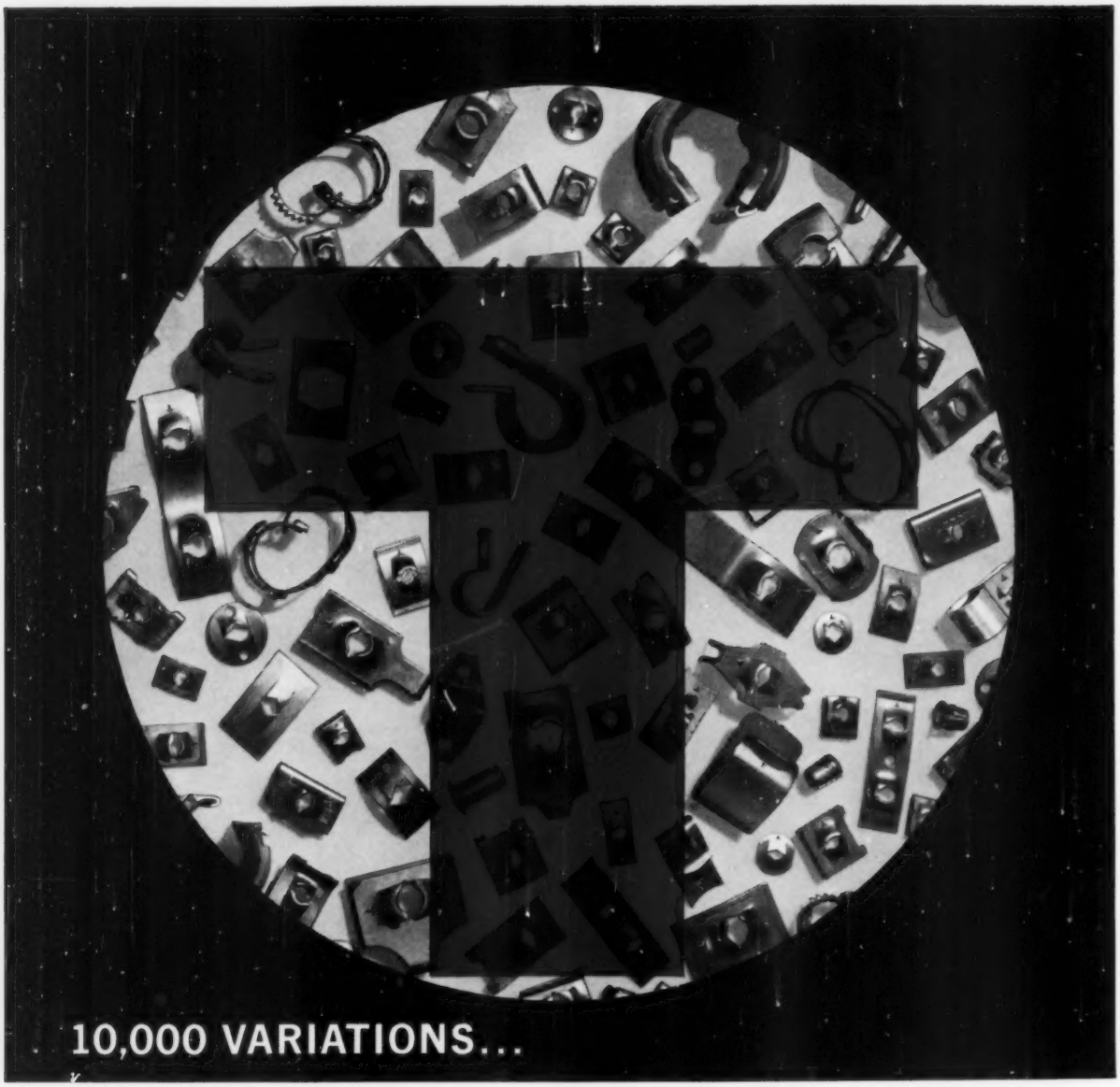

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

June 19, 1961 Vol. 32, No. 25

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Flying workhorse airlifts 80-foot power tower

Nickel in alloy steels gives 'copter transmissions extra strength for the toughest jobs

This Sikorsky S-58 is carrying a prefabricated tower to a power line construction project near Lynchburg, Virginia. After setting the towers in place, the 'copter saves time and money by helping to string wire from tower to tower.

Again, these flying workhorses prove they can handle the roughest assignments. But pilots don't want superlatives or guarantees. They want to know without doubt that critical parts will do their job. That's one big reason why nickel is alloyed into the S-58's transmission shafts and gears.

Nickel helps steel take the tremendous bending and twisting of a 'copter's drive shaft under powerful shock loads and unusual conditions.

Strength and toughness are only two properties that nickel imparts to alloys. It can help them withstand the intense heat generated by supersonic flight . . . or shrug off the intense cold of liquid helium. It also offers outstanding corrosion resistance.

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INTERESTING TO NOTE

Radio's birth cry

No single individual can claim the radio as his own invention. It took the combined efforts of several scientists working unbeknown to each other to develop the method of voice transmission. While Marconi worked in Italy, a trio of German scientists merged their efforts to form "Telefunken." In America, Reginald Fessenden, a Canadian by birth, was working for Edison's research group. Within 10 years, Fessenden made a series of contributions to this growing new science that, by now, badly needed coordination. Lee de Forest was the individual to distill the ideas of Marconi, Telefunken and Fessenden.

His first experiment in wireless telegraphy was made in 1900. Then, in 1903, de Forest was in New York City experimenting with platinum electrodes and their use in a wireless. In one hookup he connected one electrode to an aerial and grounded a second, through a telephone receiver. He heated both wires over a Bunsen flame and to his surprise received signals from a ship in New York Bay. He continued experimenting, next with a bulb that contained a carbon filament and a platinum plate. He ionized the gases within the bulb by connecting the plate to a source of high voltage. Next was the introduction of a third electrode within the bulb, consisting of a piece of wire bent back and forth and located close to the filament. This three-electrode tube, the "triode," was the prototype of the billion radio tubes that have been produced since then.

De Forest experimented at night, keeping the triode hidden in a small wooden box—only the connections showed outside. When he finally had the device working, he handed crude earphones to an associate. The latter jumped back startled: "My God, Doc, hear those signals? What you got in that box?" Within three years de Forest was transmitting music, which was being received by an ever growing number of amateur radio listeners. Finally, in the fall of 1910, radio came into its own. Enrico Caruso sang from the stage of the New York Metropolitan Opera House and his voice was heard through earphones in thousands of living rooms.

Listening to the radio in those early days was not easy—earphones literally kept you glued to the set. Listening today is much easier, maybe too easy—as the article on page 64 points out.

When standards breed trouble

Every industry relies heavily upon an exhaustive list of standards to guide the steps in manufacturing. The automobile industry has its SAE; those involved in the design or selection of electrical components use NEMA standards. (Our article on p 39 urges the updating of NEMA standards for integral-hp motors.) Over-all, ASA publishes material concerning standards for all industry. As our technology becomes more exacting, the need for precise standards and ultra-precision measurement becomes more acute.

Perhaps the first precision standard was the common poppyseed. In the 1700s it was found that the "inch"

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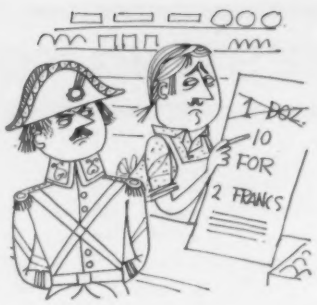
(which was the length of three barleycorns) could be further subdivided. Each barleycorn equalled four poppyseeds and each poppyseed equalled 12 human hairs. But there was no such thing as a common standard. In France, for example, nearly every city and province had its own system of weights and measures. In Marseilles today, some of the waterfront shops still use the so-called Marseilles system despite law enforcing the metric system. When Louis XVI was on the throne, a group met to discuss combining the Paris and Marseilles measuring systems, but the French Revolution intervened and the king lost his head.



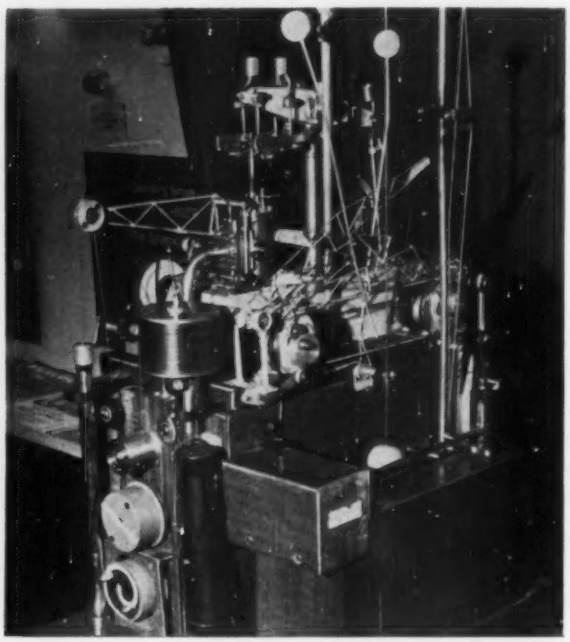
Then on May 8, 1790 the French Republican Convention imposed the decimal metric system upon the nation. But it was based on an inaccurate breakdown of metric decimal fractions of the quarter meridian running through Paris, and caused nothing but confusion. The system was so bad that it had to be enforced by undercover agents and police. Months were divided into three periods of 10 days each. Days were divided into 10 hours of 100 minutes, each containing 100 seconds. At the end of each year, five days, called "Jours Sansculottides," were left over. The law was so strictly regulated, it was a crime to sell any commodity by the dozen—you had to buy 10 or 20. All this confusion had to come to an end. The system was abolished. Moreover, on Aug 1, 1793, all scientific academies were closed, the weights & measures committee was abolished; and the following year saw the principal member of the Metric Committee, famed chemist Antoine Lavoisier, sent to the guillotine.

—Benedict A Leerburger Jr

SIDELIGHT

A counter, dozens of linkages, gears, walking beams and wheels, spin, oscillate and twitch madly on this Kliptillion with a Phobum on its Right Side. The gadget was operated at the Sealol booth in the Design Show last month and a curious reporter came up with the following details:

The Kliptillion was designed and built by John Painter at Martha's Vineyard during a long, slow winter in the Vineyard Machines and Marine Service Co, Vineyard Haven, Mass. Painter, a former GM executive, describes the uses of his invention: "It does nothing. It does it well. And it keeps track of how many times it does it."



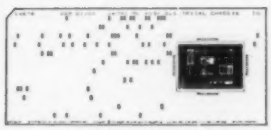
NEXT WEEK IN PRODUCT ENGINEERING

. . . **Cellular rubber gives rigid lightweight parts**
Its low-density structure is strong enough to take industrial hydraulic pressures.

. . . **Troubleshooter's approach to failure analysis**
Where and how to look for the unexpected in the newer miniaturized designs.

. . . **How good are inexpensive photodrawings?**
The author couldn't afford the expensive equipment needed for top-quality photodrawings, so he experimented with standard drafting material. Here's what he found.

. . . **Tomorrow's power sources**
If you're planning a portable machine requiring from 1 to 500 hp, chances are your choice will be limited to one of these basic 14 power generators.



Memo to the engineer who hasn't used microfilm cards as yet!

No doubt you've read about Recordak precision microfilm images mounted in aperture cards, and how they are speeding routines in drafting rooms large and small.

But you may have some questions . . . are perhaps wondering just how they can help on your job.

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WHAT'S HAPPENING IN RESEARCH . . .

New hazemeter for plastics tests

A photoelectric system that meets ASTM specifications for testing clarity of transparent plastics is being introduced by Evans Electroselenium Ltd, St. Andrews Works, Halstead, Essex, England (export distributors: Electronic Equipment Ltd, 101 Leadenhall St., London EC3).

The unit consists of a light source, lens system, spherical light chamber and photocell.

Light from the source (a 12-v 36-w tungsten lamp) passes through the lens system to form a circular spot of uniform illumination at center of the sphere. An exit port is provided on the opposite side of the sphere, with a light trap to provide a "zero," or "blank" reading. The standard for reflectance is the scattering of light from the inner surface of the sphere, which is painted white.

A specimen is clamped at the entrance port (opposite the light source) and light scattered within the sphere is measured by the photocell mounted at right angles to the light beam.

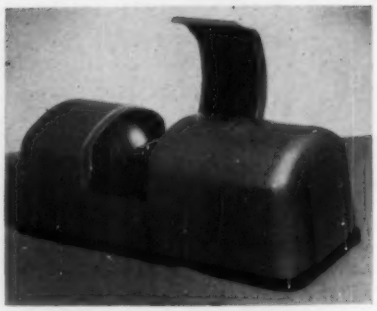
Readings are taken from a suspension galvanometer, housed with the projection lamp, controls, and scale. The galvanometer is complete in itself and can be used separately for other jobs. The hazemeter unit is 21 by 8 by 9½ in., weighs about 17 lb; the galvanometer unit is 13 by 9½ by 5½ and weighs about 8 lb.

Sinking reactor to probe earth's core?

An instrumented nuclear reactor that would melt its way through the earth's crust to provide vitally needed data on structure and composition has been proposed by W. M. Adams of Lawrence Radiation Lab. Such a system, he says, could go much deeper than the drilling method selected for the Mohole project.

The nuclear design could be surprisingly simple. The reactor would need no shielding; and, taking advantage of high-temperature materials like beryllium oxide ad graphite, it could operate in the 2000-F range.

Adams has drawn up a plan for the data-gathering and retrieval system to accompany the reactor, and has calculated the temperature gradients. No estimate has been made of costs. But, he points out, the Mohole cost is estimated at $15 million—and the reactor system might even be cheaper.



SPHERICAL HAZEMETER combines galvanometer with light-reflectance chamber and photocell. Here, lid is lifted to show sample holder, mounted at entrance port of sphere.

Low-temperature hardness charted for hard materials

Hardness of 5 wear-resistant materials at ultralow temperatures has been measured by NBS Cryogenics Lab researchers as part of a long-term program to develop bearings, pumps and other equipment for low-temperature use.

Of the materials tested—tungsten carbide, titanium carbide, Stellite 3, AISI 52100 and 440 C stainless—tungsten carbide won highest rating. Its hardness at room temperature was about 72 Rockwell C; at −109 F, 74; at −323 F, 78. At the same temperature points. Stellite 3 gave readings of approximately 55, 57, and 63. The other three were almost midway, giving readings of 62 to 65, 65 to 68, and 68 to 69.

Although all 5 materials increase in hardness as the temperature drops, and retain their relative positions, there is evidence that three—Stellite 3, AISI 52100, and 440 C stainless—approach their greatest hardness at −323 F and will not show much further increase if tested at still lower temperatures. The two carbides, on the other hand, showed an increasing rate of hardness increase as the temperature approached −323 F, and might be expected to show even greater hardness below that.

(Note: For more on the NBS bearing study, itself, see ASLE Transactions v 4, 1961 and ASME paper 61-LUBS-18.)

More wire alloys tested for resistors

Ternary platinum-rhodium alloys containing 5% cobalt or 5 to 10% chromium show good oxidation resistance and thermal and electrical properties which should permit their use in the 400 to 750-F range. NASA's Lewis Research Center reports.

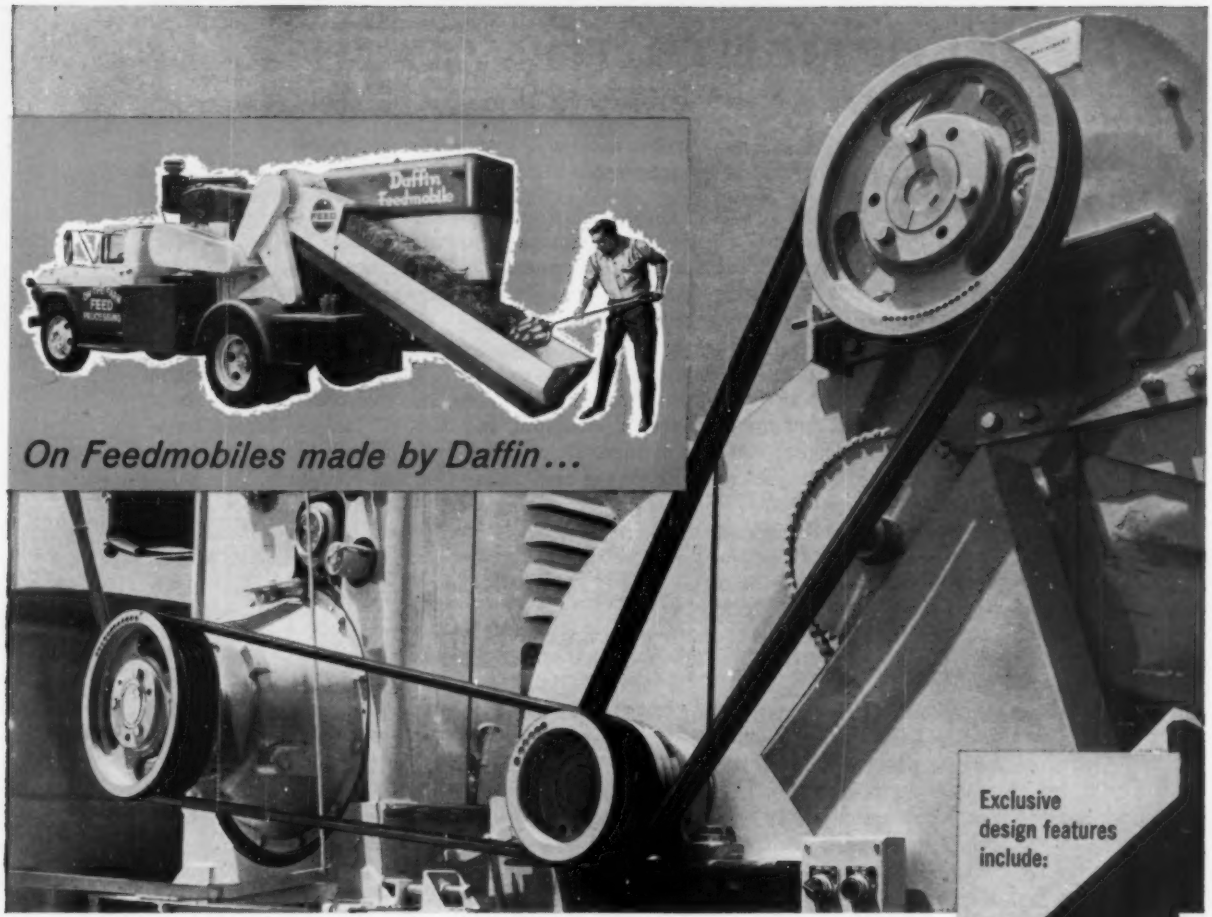
Resistivity of these alloys at 32 F ranges from 36 to 48×10^{-6} ohm-cm, compared with 20×10^{-6} for pure platinum. Temperature coefficients of resistivity are slightly higher than with the binary alloys but lower than for pure platinum. However, performance in this respect was irregular.

The alloys containing chromium (5 Cr–15 Rh–80 Pt and 10 Cr–15 Rh–75 Pt) showed constant and exceptionally high values of resistivity change per degree temperature change in the range immediately above room temperature. The data indicate a reversible transformation takes place in the lower-Cr alloy near 320 F and in the higher-Cr alloy near 960 F; but these alloys were electrically stable to 1800 F.

The cobalt-bearing alloy seems especially suitable for temperature-stable resistors, and the chromium for thermometric applications.

Bevatron Baedeker

A glossary of terms used in high-energy physics, with a table of elementary particles, has been prepared by American Institute of Physics as the fifth in its series of definitions of the new terms of science. This one, a 20-p printed booklet, covers *accelerators, mesons, wave functions*, and well over 100 other terms. Single copies are being made available to PE readers without charge while supplies last. Requests should be addressed to Audrey Meyers, AIP, 335 E 45th St, NY 17. **–ARG**



Gates Super HC Drives permit power increase of 20hp in less drive space

The Daffin Feedmobile is a well-designed, efficient feed mill on wheels made by Daffin Manufacturing Co. of Lancaster, Pennsylvania. Originally, all the power for grinding, mixing and blending was transmitted by conventional V-belt drives.

Early in 1960, the machine was redesigned to obtain the competitive advantages that result through use of Gates Super HC High Capacity V-Belt Drives.

An official of the company, John Skinner, Jr., says: "The Gates Super HC Drives let us increase the output of the diesel power plant from about 100 HP to 120 HP without reducing the original safety factor. Sheaves are narrower and are about 80 pounds lighter, reducing the overhang load on bearings, increasing bearing life. Guards are 4 inches narrower, require less metal and are nearly 33% lighter weight. Drive cost for each machine has been cut 7 or 8%."

He says further: "The Gates High Capacity Drives have greatly strengthened one of our most important selling points—the fact that 'there is far less down-time with a Daffin.'"

Manufacturers everywhere have standardized upon the Gates Super HC V-Belt Drive —the first and most advanced high capacity drive. It is your best assurance that your power transmission unit will not soon become obsolete.

The Gates Fieldman located near you is a drive design expert. Contact him for technical information and assistance in designing Gates High Capacity V-Belt Drives.

Exclusive design features include:

precisely engineered arched top, concave sidewalls, Flex-Weave cover, super strength tensile construction.

Gates Super HC Drive saves space, weight and money

The Gates Rubber Company, Denver, Colorado

BP 150

Gates Super HC V-Belt Drives

Building the future on 50 years of progress.

DEVELOPMENTS TO WATCH...

Nickel alloys gain strength and heat resistance

New ultrahigh-strength casting alloys and dispersion-hardened powder products are among the improved nickel materials announced in recent months.

One of the new casting alloys is already commercial. This is Inco's IN-100 *(PE—Apr 10, p 67)*, said to show "higher rupture strength at all temperatures to 1900 F than any superalloy thus far announced."

Still under test are high-strength casting alloys that promise to develop excellent stress-rupture characteristics without vacuum melting. Like IN-100, they contain substantial amounts (6 to 8%) of aluminum, chromium, and molybdenum, with about 1% Zr and small amounts of tungsten, vanadium, and carbon. Defense Metals Information Center reports that one of these alloys had a stress-rupture life of 768 hr at 1800 F and 15,000 psi, nearly twice that of cast Udimet 700 and Nicrotung.

Among the powder-metallurgy compositions is a group of dispersion-hardened nickel-base materials, made by extruding mixtures of nicket powder with partly oxidized nickel-aluminum powder to produce a nickel-alumina composition. Nickel-magnesia compositions are also under test, and preliminary reports indicate their strength will nearly equal that of Inconel X at 1800 F.

Tachometer has only 3 major parts

A tachometer that consists simply of an anode, a cathode, and a rotating cylinder; and, in its final form, should fit in a glass envelope, no bigger than a standard vacuum tube, has been developed by Prof W. H. Middendorf, of U of Cincinnati.

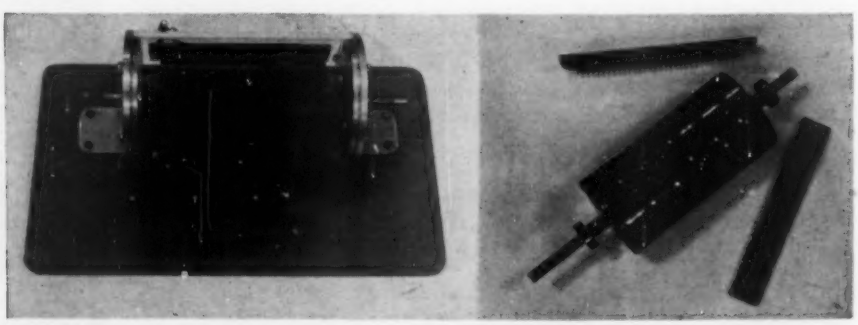
In the prototype (see photos), the anode and cathode are simply two rows of steel needles mounted on 3/32-in. centers in a back-up plate. The rotor is an aluminum cylinder, wrapped with self-adhering silicone tape and then coated with Formvar.

In operation, a dc voltage sufficient to cause high field emission is placed between the electrodes. Electrons leaving the negative electrode are drawn toward the insulated rotor. Here, they are trapped on the outer surface of the insulation, so they tend to prevent other electrons from leaving the electrode points. When the rotor is stationary, this buildup of charge quickly reduces electron flow to zero and the device acts as a very small (approximately 20 $\mu\mu$f) capacitance capacitor.

But, if the rotor is made to rotate, the area covered with electrons moves away from the negative electrode and other electrons are emitted to the new, uncharged areas of the rotor as they pass under the electrode points. These electrons are then picked up by the anode and returned to the positive terminal of the dc supply.

Flow rate of electrons is given by a voltage-measuring device connected across a resistor placed in the series circuit. A capacitor is also placed across the resistor to minimize high-frequency noise.

Tests show that output voltage varies directly and linearly with respect to speed, and zero output voltage is obtained at zero speed. Middendorf also notes that the system has very low friction and inertia.



PROTOTYPE DIODE TACHOMETER has comb-type electrodes, is encased in plastic housing. Commercial model would be encased in glass vacuum envelope (to reduce h-f noise) and a system of thermionic emission might be adopted to reduce applied-voltage requirements. Tungsten needle points might replace steel for the same reason.

New stator insulation designed by Swiss

A low-loss insulation, resistant to aging and serviceable at temperatures to 300 F, is claimed by Brown Boveri of Baden, Switzerland. It combines glass fabric, mica, and a modified epoxy impregnating resin in a wrapping which, BB says, offers a number of advantages as compared to previous systems (resistance to creep, elimination of junctions that characterize pressed slot insulation).

The glass fabric serves as a carrier for the mica and is bonded by the synthetic resin; and, says BB, the resulting combination shows a high dielectric strength, an electrical resistance on the order of 20×10^{12} ohm of 500 v dc, and excellent flex resistance (better than 50,000 cycles before breakdown).

More light from electroluminescent sources

Brighter area-light sources for instrument panels, clock faces and data display are promised by research now underway at several labs.

A new technique developed at Lockheed (Sunnyvale, Calif.) for chemically coating individual phosphor particles with a transparent, high-dielectric layer, is reported substantially to increase light output of electroluminescent panels by changing the brightness-voltage characteristic. The reason: The binder material in which the EL phosphor is dispersed plays an important role in placing a large portion of the applied voltage across each phosphor particle; and phosphor brightness depends highly on voltage.

Basic studies at Stanford Research Institute reported at a recent Electro-Optical Systems conference, may also lead to improved electroluminescent devices. Here, methods are being sought to convert into light some of the heat energy liberated by the recombination of dissociated molecules. The method: catalysts that possess luminescent centers capable of absorbing, and becoming activated by the recombination energy. The luminescent centers then emit photons with a characteristic energy. The catalysts in the initial tests are impurity-activated calcium oxide and magnesium oxide, and the ionized atoms are nitrogen, produced by electrical discharge.

Work here is still in its early stages but may pave the way for new analysis techniques as well as improved electroluminescent devices.

(Note: For more on electroluminescence and its design applications, see *PE—July 18 '60, p 57, Aug 8 '60, p 10, and Oct 3 '60, p 41.*)

Silicone rubber tested for ablative coatings

Thermal insulating properties of silicone rubber are vastly superior to those of other ablative materials, according to M. E. Groby of GE's Silicone Products Dept. He says it can stand temperatures at least to 5500 F for several minutes and still show good thermal insulating properties. Its thermal conductivity is low, and it forms a hard, tenacious, porous surface char.

Recent tests, reported to the CSMA mid-year meeting, indicate that silicone rubber's effective heat of ablation is "as much as 8 times larger than some of the plastics now used; its rate of ablation 7 times smaller; and its weight loss substantially lower." Further tests are now in progress.

Solar engines begin to look promising

Thermal engines that use the sun's rays as a heat source are making rapid progress.

Farrington Daniels of U of Wisconsin, long-time proponent of solar energy, told a National Academy of Sciences symposium that new approaches promise to solve one of the most crucial engine design problems: how to obtain a rapid transfer of heat from outside to inside. One good idea: using a transparent window in a hot-air engine to admit focused solar energy.

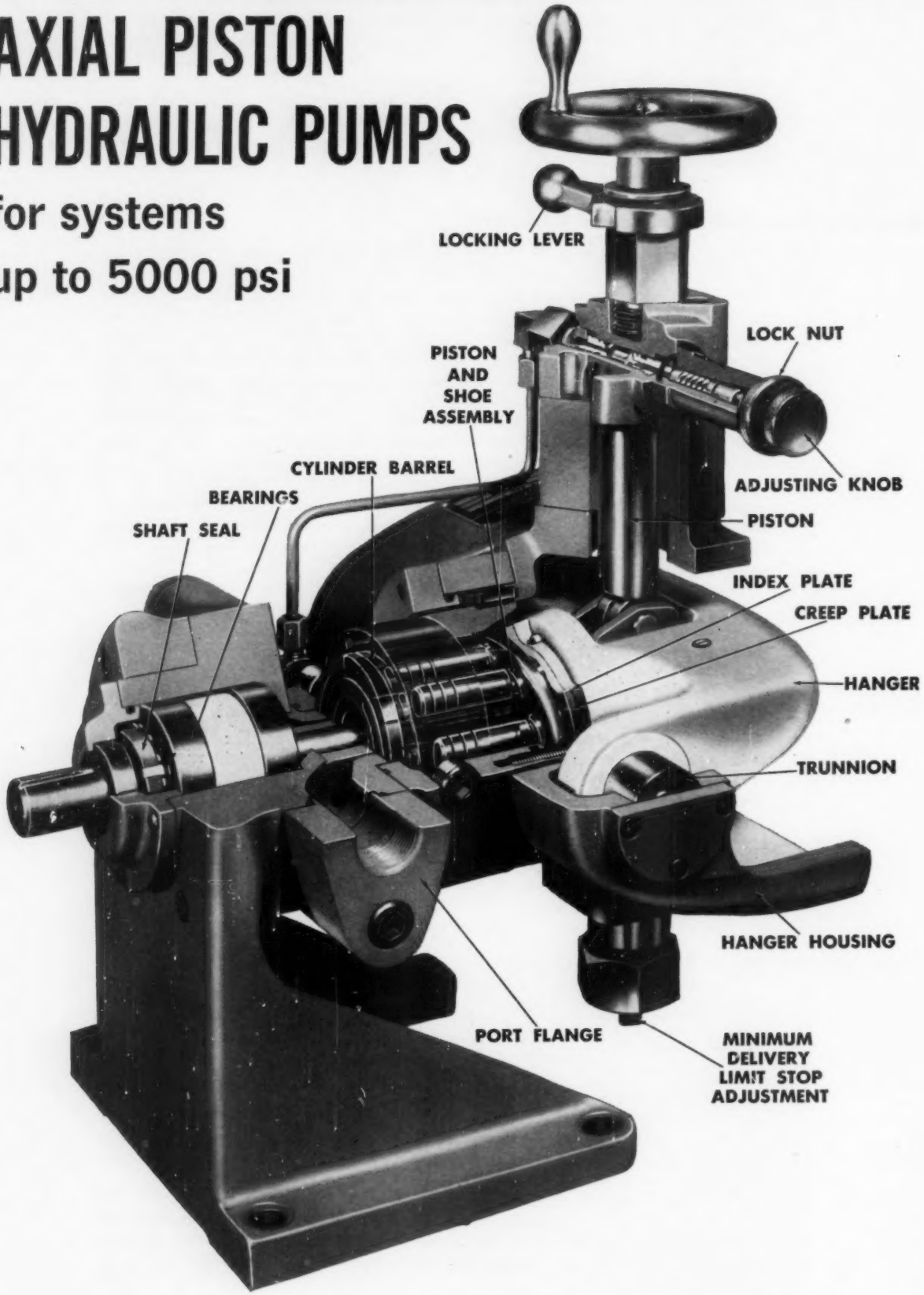
Performance of heat engines in the smaller sizes can also be improved considerably by use of new organic working fluids. Scientists at Israel's National Physical Laboratory say solar heat engines in the 3-5 kw range have shown efficiencies of 15-20% at operating temperatures of 300-400 F.

John Wintringham of Ethyl Corp says improved Stirling engines (*PE—Aug 25 '59, p 7*), using hydrogen as a working fluid and solar energy as a source of heat, now seem capable of achieving efficiencies in the 35 to 40% range—comparable to that of a large steam turbine powerplant. If they live up to expectations, they might well prove adaptable for space flight. **—ARG**

Design of variable volume

AXIAL PISTON HYDRAULIC PUMPS

for systems up to 5000 psi



By: Ellis H. Born
Director of Sales-Engineering
Denison Engineering Division
American Brake Shoe Co.
Columbus, Ohio

With today's ever-increasing requirements in the transmission of higher horsepower, the designer must look to hydraulic components that will give the greatest transmission efficiency with the lowest possible cost and the smallest possible package. With smaller, lighter, more powerful equipment—operating pressures of 2000, 3000 and 5000 psi are becoming commonplace. To meet the needs of higher pressures with a high degree of reliability, axial piston pumps and motors of proper design should be considered.

For 5000 psi requirements, the axial piston pump (illustrated) is a logical choice. It operates on the principle of a series of pistons in a common barrel that progressively draw oil into the barrel on the suction stroke and force oil from the barrel into the line on the discharge stroke.

With this simple axial piston design, direct and unrestricted flow into the pumping assembly is possible, eliminating the need for the large flow areas used and the moving seals which, in turn, eliminates maintenance. Direct flow path further insures good suction characteristics —a highly desirable operating advantage for obtaining efficient hydraulic performance.

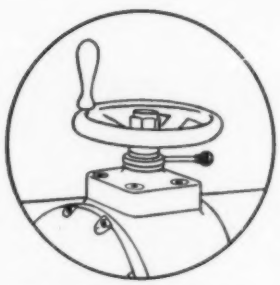
The port plate of the Denison pump is designed as an axial hydrostatic bearing which balances out the thrust of the cylinder barrel, leaving only sufficient force to create a positive seal contact between the cylinder port plate and the cylinder barrel. Because of reduced thrust, wear on mating surfaces is decreased and pump life is greatly extended at all pressures up to 5000 psi.

Where variable volume is required, it is logically desirable (for efficiency, simplicity and low maintenance) to eliminate the need for varying the position or angle of the cylinder barrel to regulate volume. In the Denison axial piston pump, output up to 125 gpm is simply regulated by varying cam plate angle. Zero to full flow or flow reversal is regulated by handwheel, hydraulic cylinder, stem, electric motor, compensator or electrohydraulically.

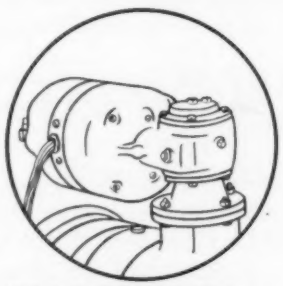
In the Denison design, the line of action of the combined radial load of all pistons is through the roller bearing supporting the cylinder barrel. The use of a large bearing provides non-deflecting support for these radial forces. As a result, unbalanced or twisting offset that would tend to unseat the cylinder barrel from the port plate is eliminated. A continuous, effective sealing action of the barrel against the port plate is maintained to promote high pumping efficiency.

Piston and shoe assembly design also reduces by one-half the number of ball and socket couplings found in other types of axial piston pump construction. The shoes hydraulically balance out all piston thrust, eliminating need for thrust bearings.

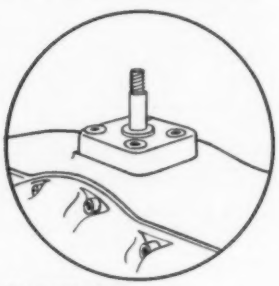
Data and specifications on 5000 psi pumps, motors and controls are available from your Denison representative—located in principal cities—to assist you in developing hydraulic systems for maximum efficiency and economy.



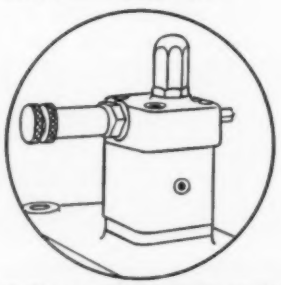
HANDWHEEL CONTROL
...with locking device for accurate manual pump volume regulation.



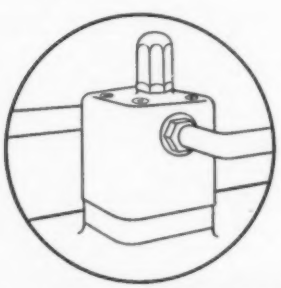
ELECTRIC MOTOR CONTROL
...adjusts pump volume to desired level. Integral brake in gear-head motor eliminates over-travel.



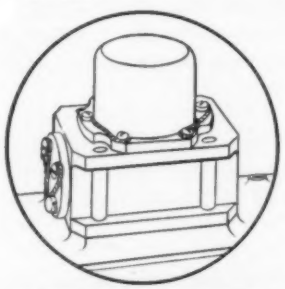
STEM CONTROL
...provides mechanical linkage to the driven equipment.



PRESSURE COMPENSATOR CONTROL
...affords automatic regulation of pump volume to meet preset pressure demands.



HYDRAULIC CYLINDER CONTROL
...similar to stem control, except volume is hydraulically regulated.



ELECTRO-HYDRAULIC CONTROL
...utilizes sensitive, system error-detecting unit which energizes hydraulic volume control piston.

NEW CATALOG FOR DESIGNERS AND ENGINEERS

Write for your copy of Bulletin 220—"Hydraulic power to 5000 psi". Includes complete specifications, operating data and applications for Denison's full line of hydraulic pumps, motors and controls.

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FROM WASHINGTON . . .

Government enlarging staffs to administer research

The Federal government's procedure for spending on research ($9 billion this year) is due for major overhaul by the White House. The setup will be run through the Federal Council for Science and Technology, under direction of the President's science advisor Dr Jerome B Wiesner.

This council was established in 1959 by President Eisenhower, but much like the National Space Council, never functioned to any major degree.

Now, staffs are being enlarged with direct responsibility to set national goals for research, coordinate government agency efforts, and provide the means for accomplishing the goals.

Three prime areas will get immediate attention from the council. Top priority will be given to establishing a central inventory of research so that one office will have over-all knowledge of all government research being conducted.

Secondly, the council will work toward getting better management of federal research programs. And, thirdly, it will explore the possibility of using more foreign scientists to conduct research for the US.

With the annual federal expenditure on research growing rapidly, many influential congressmen are demanding better guidance and control for the programs. Reportedly, an ultimatum has been laid down to the Administration; that it get better grip on the matter or Congress will set up its own controls.

Hinged tower designed for servicing Saturn

A uniquely designed service tower that can handle a pair of space-launching pads has been developed for the National Aeronautics and Space Administration. Slated to service advanced versions of the 1.5-million-lb-thrust Saturn vehicle at Cape Canaveral, Fla, the unit was designed by Maurice H Connell & Associates Inc, Miami.

Construction of the tower and the launch-pad complex will start early this fall. Towering some 380 ft high, the structure's six hinged levels will swing in around the big space booster to service it. Before a firing, it will move on tracks 1000 ft or so clear of the pad. Trackage allows the single tower to move the 1200 ft between the two pads to service either one. Cost of the two-pad complex will run about $20 million and take about a year to complete.

A smaller service tower, designed to straddle a single launch pad, was officially completed on June 5. It will serve to fire the first Saturn test shots this year. Also designed by Connell Associates, the present tower stands some 330 ft high and weighs 2800 tons.

The new Saturn launching complexes, built 1200 ft apart, will put the three-man Apollo vehicle into earth orbits and on trips around the moon. A third complex will be built later to handle a 12-million-lb-thrust vehicle that will land the Apollo vehicle on the moon.

Original plans called for having one tower service the first three Saturn launch pads. But, the danger of having one of the big boosters explode and damage the tower caused the space agency to order a second to ensure that the man-to-the-moon program is not delayed for lack of a service tower.

LEXAN® RESIN MAKES NEW AIR DIFFUSER DESIGN POSSIBLE

A new concept in air distribution—pioneered by Carnes Corporation of Verona, Wisc.—made a reality by LEXAN polycarbonate resin!

In Carnes' design, 6-by-6-inch air diffusers, like those above, form modular units which can be arranged in any desired ceiling pattern. Three different module designs provide complete flexibility in directing air.

"LEXAN resin is the only material we have approved for our diffusers," says Gordon Sylvester, Chief Product Engineer of Carnes. "We tried polystyrenes, polyethylene, nylon and others, but they all fell short in one way or another."

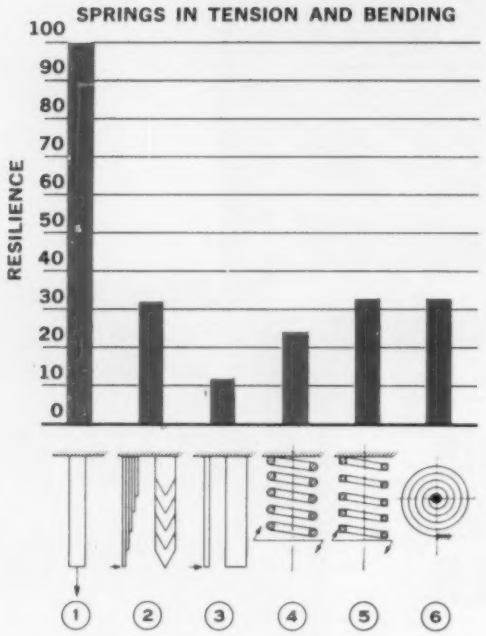
The material for Carnes' diffusers had to meet this combination of requirements: • INJECTION MOLDING for low production cost. LEXAN resin, as a thermoplastic, gave this advantage. • NO HEAT DISTORTION in 225°F. test for handling warm air. In month-long tests of parts, LEXAN resin met this spec. Actually, the resin's rated distortion point is 270-280°F. under load. • DIMENSIONAL STABILITY in use. LEXAN resin was stable. • FLAME RETARDANCE to pass ASTM test. LEXAN resin passed. • COLOR STABILITY and versatility. Although the modules are now a stable white, LEXAN resin offers the possibility of a wide range of colors. • HIGH IMPACT RESISTANCE. Frank Freese, Product and Merchandising Manager for Carnes, really sells LEXAN resin's enormous impact strength. He says "In demonstrating the strength of the modules, we slam them against the wall. It doesn't damage them at all. Metal diffusers would be bent by this treatment."

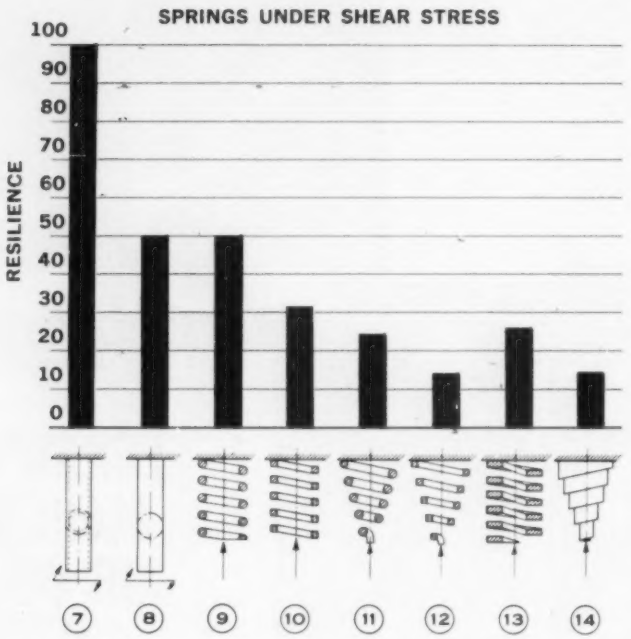
LEXAN resin has raised the quality of many designs to new levels. It's been substantially reduced in price as new G-E plant facilities have come onstream. Can this tough new thermoplastic help you? Send for design literature. Address General Electric Company, Chemical Materials Dept., Section PE-61, Pittsfield, Mass.

LEXAN®
Polycarbonate Resin
GENERAL ELECTRIC

CIRCLE 13 ON READER SERVICE CARD

What Type of Spring to use ? Here's a quick comparison of relative efficiencies

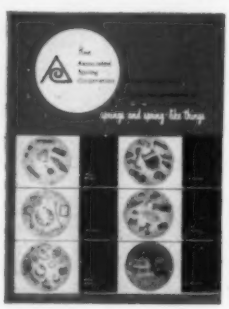




1. Simple flat spring
2. Leaf spring
3. Rectangular flat spring
4. Round wire compression spring
5. Square wire compression spring
6. Flat wire spiral spring
7. Thin wall tube
8. Solid rod
9. Round wire spring
10. Square wire spring
11. Round wire conical spring
12. Square wire conical spring
13. Rectangular wire spring
14. Volute spring

Relative efficiency of various types of springs can be compared on the basis of energy-absorbing capacity per cubic inch or per pound of metal in the active portion of the spring. For theoretical purposes the simplest forms—wire in tension (1) and thin-wall tube in torsion (7)—represent the ultimate, since all their fibres are stressed alike. The comparisons shown above assume springs are of metal of equal quality, able to withstand the same fibre stress. Obviously, other considerations may affect spring selection such as space available, material desired, atmospheric conditions, manufacturing cost, etc. So efficiency is often tempered by expediency.

If you're embarking on a project requiring springs, tap the knowledge and years of experience available from Associated Spring and its divisions. *Write for "How A.S.C. Solves Design and Production Problems of Springs and Spring-Like Things."*



6103

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
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Dunbar Brothers Division, Bristol, Conn.
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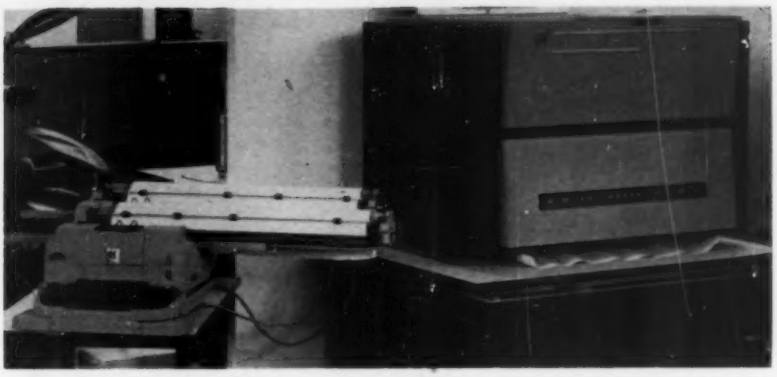
Milwaukee Division, Milwaukee, Wis.
Seaboard Pacific Division, Gardena, Calif.
Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que.

The European look captures French instrument show



Speed in logging data from temperature and pressure gages, flowmeters and other measuring instruments is provided by this transistorized unit, which checks transducers from 100 instruments in 65 sec. Transducer output is converted into a 4-digit decimal number with an accuracy of 4 parts in 10,000. Half the channels can operate at any one of three voltages, giving full numerical output for 40 mv, 10 v or 150 v dc. The equipment was shown by Campagnie Generale de Telegraphie sans Fil of Paris.

PARIS—The concept of a continental, rather than national, market is catching the European imagination. And it is beginning to show in industrial equipment—strikingly similar designs are now emerging from different countries. This trend toward international design was what strongly impressed many visitors at the Mesucora (MESUre, COntrole, Regulation et Automatisme) Show here.

Though the show was originally organized for Frenchmen to sell their products to other Frenchmen, so many foreign companies took display stands that the show became a truly international affair. Some 391 French and 339 foreign exhibitors from 17 countries participated. In the vanguard were 110 German manufacturers, trailed by 87 from the US, 60 from Britain, and 38 from Switzerland.

The French contingent showed nothing radically new, but demonstrated that they will be strong contenders for just about every branch of the industrial-controls market in Europe, except numerically controlled machine tools. Only one French machine-tool system was there—and it was a prototype developed by a government research lab.

Many observers considered French data-logging equipment topnotch, especially that shown by Compagnie General de Telegraphie sans Fil. (See photo.) In process-control computers, the French have gained strength through union with US companies. For example, Compagnie Europeenne d'Automatisme Electronique, a joint effort involving two firms here and Thompson Ramo Wooldridge, showed its RW-300 computer. One of the units is now being installed at the Chinon nuclear power station as part of a system for detecting rupture of fuel cladding. Another is being installed at a conventional 250-mw thermal power station outside Paris for computing specific fuel consumption.

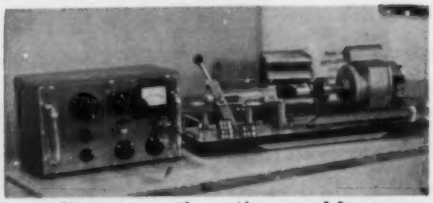
Another joint endeavor, this one a license agreement between Compagnie des Compteurs and Packard-Bell, is attempting to crack into the chemical process market with PB's 250 computer. The French partner attracted attention on its own with an endless-tape programming unit for an automatic conveyor-loading system. In this system the weight of material deposited on the conveyor by each hopper is coded on tape, which then acts as an analog of the conveyor. Tape readout initiates hopper discharge, keeping discharge going until weight on the conveyor checks with information coded on the tape.

French exhibitors also displayed an imposing array of nuclear instrumentation equipment. The French Atomic Energy Commission showed an electrostatic relay that picks up output as low as 10^{-11} coulombs from radiation-detection devices. Output charges are stored on a blade until electrostatic forces reach a preset value. At this value, force is enough for the blade to be attracted to the magnet, closing the contacts and "resetting" the blade to zero. Precision of the calibration is 0.5×10^{-8}, repeatability 2%, contact life around 10^{10} operations.

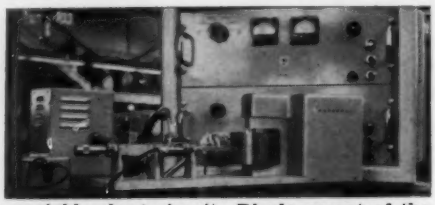
All five French contenders for the static-switching market showed up with transistorized logic elements, suggesting that development in this area is accelerating. One manufacturer estimated that his static-switching business this year will triple last year's; another expects doubled sales.

Among other exhibits that drew interested crowds at Mesucora were:

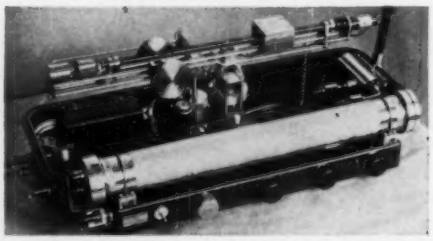
• An epicyclic motor for a servosystem, which runs at speeds down to 10 rpm without gear train. To get low output speed, the rotor is mounted on two rubber-surfaced wheels, slightly smaller in diameter than the stator bore. While the rotor wheels run around the inside of the stator at 3000 rpm, the rotor slowly describes a circle about the axis of the motor. This slow rotation is picked off through an elastic linkage to drive the output shaft. Speed depends on the difference in diameter between rotor wheels and stator bore; standard models develop 10, 30, 60 or 100 rpm. The motor is slightly under 6 in. dia, develops starting torque of 370 oz-in.; starts, stops or reverses in 1/100 sec. Its manufacturer is SFAIRE.



Believing that a meter is more reliable than the human ear for detecting noisiness of motors, bearings, etc, French sonic specialists SIDAS of Vitry-sur-Seine have developed this selective noise-meter. It picks up sound in the critical-frequency range, determined by readings across the entire sound-frequency spectrum of a component known to be good, and converts these to a reading in picawatts. Lab versions of the instrument cover the entire audible-frequency range; industrial models cover only the critical range for a specific component.



By reflecting microwaves off a rotating component this unit simultaneously measures eccentricity and surface irregularities or vibrations under dynamic conditions. The system of standing waves is set up in a waveguide. Waveguide need not touch the piece, which acts as a variable short circuit. Displacement of the piece causes a shift in the standingwave pattern (a surface irregularity is a displacement so far as the equipment is concerned.) This shift is detected by a crystal whose output signal is fed to an oscilloscope, calibrated to permit readout of eccentricity and surface irregularities. This equipment is made by Philips-Industrie of Bobigny.



Continuous and accurate measurement of gas pressures is reported obtained by driving a weight along the balance arm of this pressure gage until it equals the force developed by a piston which is ported to the gas being monitored. When equilibrium is upset by a pressure variation, the balance arm closes one of a pair of closely spaced contacts, and a servomotor drives the lead screw on which the weight is mounted, until equilibrium is restored. The pressure reading is picked off by a turns-counter on the lead screw. Its manufacturer is Desgranges & Huot of Aubervilliers.

Noteworthy primarily for versatility this numerically controlled machine tool has its program punched on a sheet which is wrapped around a drum. The sheet has 100 lines, each containing instructions for one X, Y or Z movement. The control equipment electrically reads the output-shaft position indicated by a mechanical turns-counter, then compares it with instructions on the line. Resulting signal is fed to an electromagnet clutch and drives shaft until counter is within two turns of programmed position. Then control shifts automatically to a "precision drum," accurate to 1/100 of a turn, for the approach to position and stop. When instructions for a line are carried out, the program drum advances automatically to the next line. Invented by the Industrial and Maritime Science Research Center at Marseilles, the unit is believed producible for about $3000.

• A drilled ferrite plate memory unit with capacity of 10, 240 bits. The plates are in a stack of 40, each has 256 holes. Ferrite around the holes acts as a conventional ferrite toroid. Material in the plates has conductivity low enough to permit reading the readout circuit directly on the plate. Centre Nationale d'Etudes des Telecommunications developed the unit.

• Miniature metallic bellows made of copper alloy and stainless steel. ID of the seamless bellows is slightly less than 3/16 in. The manufacturer, Blondelle, says they are the smallest available, as far as he knows. He also says present limitation to miniaturization is the size of tubing on the market.

—Art Erikson, Regional Editor

Data processors ask ASA to write industry standards

NEW YORK—Standards for numerical control of machine tools and process control computers may be forthcoming. Twelve user and producer associations in the data-processing field have asked the ASA to write such standards. Work will begin later this year pending approval of the project by the Miscellaneous Standards Board of the ASA.

Recommended scope of the project calls for measurement and specification of electrical and other physical characteristics of functional components and equipment used in and with computers and numerical process controls. Specific tasks urged on ASA were:

• Methods for specifying analog device sensitivity in industrial process control.

• Codes for feeding information to machines in machine-tool numerical control.

• Consideration of characteristics of the interface between the transmission medium and the computer in data transmission.

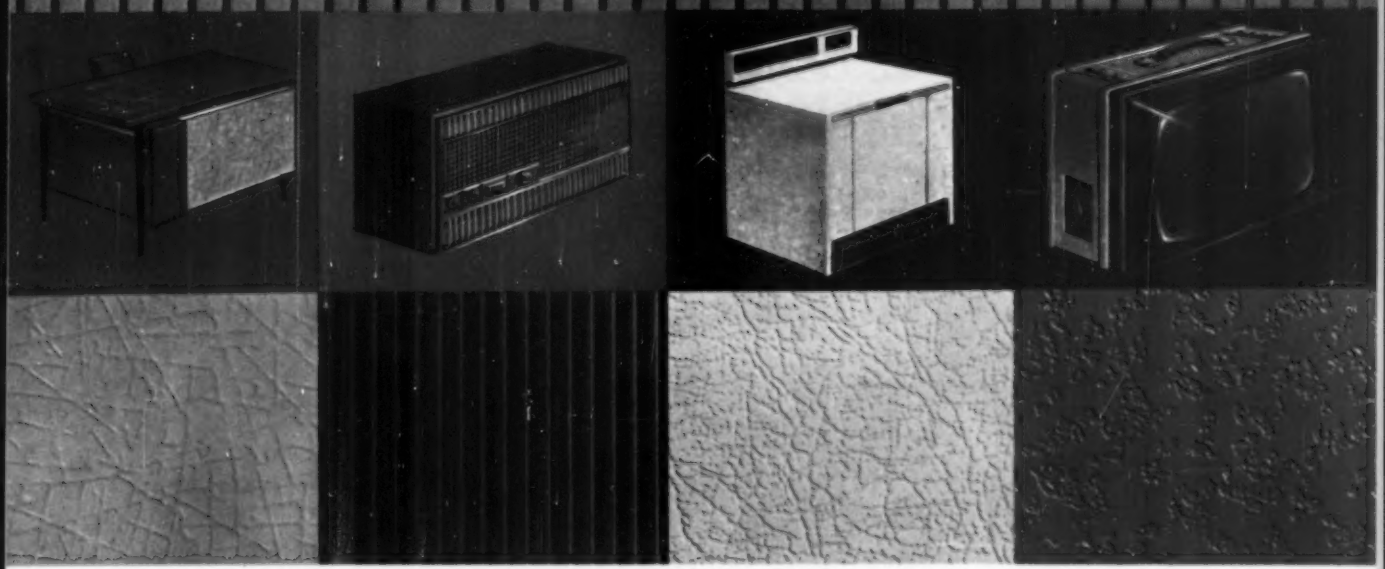
• Consideration of measurement and description of characteristics of media such as cards and tape used with input-output equipment.

The project has been spearheaded by the Electronic Industries Association. Others participating in the planning include ASME, AIEE, IRE and the Aerospace Industries Assn. ■

news continued on page 21

CIRCLE 17 ON READER SERVICE CARD→

PICK A PATTERN FOR YOUR PRODUCT FROM PITTSBURGH STEEL SHEET



Wrapper stock or drawn parts, flat panels or roll-formed fittings—whatever the application, Wide Pattern Designed Sheet gives finished products snap and sparkle that attract buyers, boost sales. Patterned Sheet—as wide as 60 inches, thicknesses from .0179 to .0897 inch—is available in commercial, drawing and AK drawing quality steel; has same fabricating properties as plain cold-rolled sheet in your processing equipment. Rolled-in designs—unlimited in range—take paint, enamel, porcelain, plated finishes. Investigate Wide Pattern Designed Sheet—steel with decorative appeal, from . . . PITTSBURGH STEEL COMPANY, Pittsburgh, Pa.

for other steel specialties turn page.

HOW "BOSTON" PROFITS FROM THOMAS NICKEL-COATED STRIP

Thomas Strip buffed nickel-coated steel strip reflects 40% saving, fewer production steps for C. Howard Hunt Pen Co.'s pace-setting "Boston" pencil sharpeners.

At Statesville, N.C., Hunt Pen blanks, embosses, pierces, spot-welds wrapper stock for sharpener cases from coils of 2 by .010-in. buffed nickel-coated steel. Firm has depended on Thomas Strip Division of Pittsburgh Steel Co. 20 years for brilliant finish. Purchasing Agent T. V. McCurdy tells why:

"We once used stainless for wrapper stock but costs skyrocketed. Thomas Strip costs 40% less, gives us handsome appearance, durability and easy fabrication of steel. It eliminates expense and headaches of plating, too.

"We're more critical of this material than any other—the slightest scratch stands out. We've never had to reject any during our long relationship with Thomas."

Hunt Pen produces more pencil sharpeners with nickel-plated strip than any other U.S. manufacturer. Assembly of "Champion" portable model is shown above.

Want to learn how Thomas Pre-Coated Strip Steel Specialties can help you? Ask, and we'll show you.

"WE GET BETTER PRODUCTS FOR LESS WITH THOMAS PRE-PAINTED STRIP," SAYS NATIONAL GYPSUM COMPANY

Tough, durable vinyl-enamel coat on Thomas Pre-Painted Strip fabricates easily as plain steel, gives a profitable boost to "Gold Bond" quality of National Gypsum Company's metal building products.

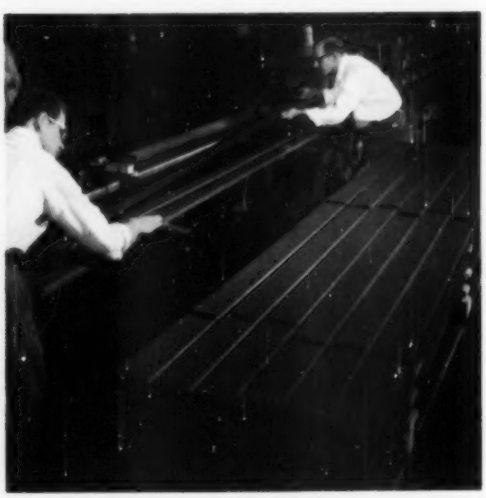
Exposed pre-finished partition bases, cornice moldings, wall trim and "J" suspension channels are roll-formed by National Gypsum Company's Niles, O., Metal Building Products plant. Coiled strip sizes range from 18 to 24 gage in widths $2\frac{17}{32}$ to $4\frac{1}{2}$-in., painted one side with white, grey or red, and wash-coated opposite side.

"Thomas Strip Pre-Painted gives us products far superior to those we got when we spray-painted after forming. It saves us 8.75 to 9.2% of production cost and reduces inventory problems," says Plant Manager D. K. Archer.

"The paint coat has better adhesion and takes roll forming without cracking or peeling. Thomas supplies us superior material of uniform, consistent quality that suits our requirements."

Photo below: roll forming 10-ft. Snap-On bases.

Eliminate your paint-line problems with Thomas Pre-Painted Strip. Let us show you how.



PITTSBURGH STEEL COMPANY

SQUEAKS, RATTLES SILENCED WITH THOMAS PLASTIC-COATED STRIP

Primary use of Thomas Plastic-Coated Steel is in decorative applications. But it performs a unique practical task for manufacturers of fine furniture.

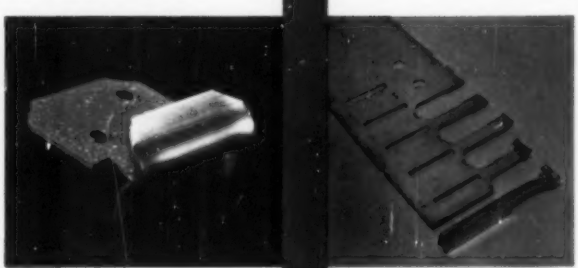
Laminated to Thomas cold-rolled strip, the plastic coating assures absolutely noiseless functioning of modern, strong steel springing.

Universal Wire Spring Division of Hoover Ball & Bearing Co., Georgetown, Ky., uses Thomas Plastic-Coated Strip to make spring retainer clips that anchor its sinuous wire Uni-Torq and Uni-Flex springs to furniture frames.

"We tried applying pressure-sensitive tape to steel for this clip, but decided on Thomas Plastic-Coated. It's pre-finished and doesn't slip or peel in forming or in use," says Bernie J. Johnson, sales vice president, upholstery spring division.

"The clip acts as a pivot as well as an anchor for our engineered seating springs. Steel against steel produces squeaks and rattles. The plastic coating eliminates them—and makes an important sales point."

Decorative or functional—whatever the need, Thomas Steel Specialties will make your product better, too.



THOMAS STRIP HELPS "BUILD A BETTER MOUSETRAP"

World's biggest trapmaker, Animal Trap Co. of America, has the long-sought "better mousetrap." And Thomas Strip Copper-Coated Steel helps make it so. Rattraps, too.

Animal Trap Co. of America, Lititz, Pa., has depended on Thomas Strip over 25 years for close tolerance copper-coated steel strip to make bait pedals, locking bars for a dozen models.

The firm produces millions yearly from Thomas electroplated stock in sizes from .4375 by .025-in. to 5 by .035-in., #2 temper. Precise tolerances, consistent temper of base steel allow long, trouble-free runs through progressive dies, automated assembly lines.

"Base steel gives strength, economy—the planished copper finish provides appearance and corrosion resistance needed to out-sell cheap foreign-made traps," says Sales Vice President D. S. Morrison.

Want the world to beat a path to your product's door? Thomas Strip plain or coated steel specialties may be what you need. Ask.

PITTSBURGH STEEL COMPANY

BRASS-COATED THOMAS STRIP SAVES FOLDING-RULE MAKER 60% IN METAL COST

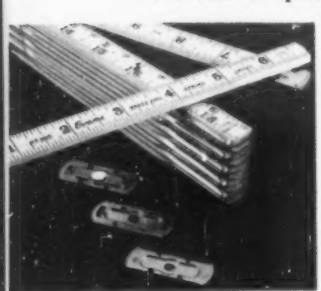
Thomas Strip Brass-Coated steel measures up to strict cost, tolerance, strength and appearance standards for Evans Rule Co. of Elizabeth, N.J., leading producer of measuring rules and tapes.

An improved type of wood folding rule—assembled with 11 patented spring joints, fabricated from Thomas electro brass-coated strip—is produced for Evans by a subsidiary—Fabrule Co.—in a fully automated plant.

For rule joints, Evans buys two sizes of Thomas brass-coated strip—1.812 and 1.562 in. wide by .012-in. thick, #3 temper, planished and oiled.

"Brass-coated strip saves us about 60% over what we'd pay for pure brass for rule joints," says John J. Evans, board chairman.

"Besides that, the base steel supplies strength to take abuse, as well as rigidity needed when the rule is opened. The brass coat provides protection against corrosion and the planished finish results in a sales boosting appearance. Physically, width and temper uniformity is critical for processing through our automated lines."



Do expensive metals hike your product cost? Inquire how Thomas Strip pre-coated steel can help you save.

The STEELMARK on a product tells you it is made of steel. Look for it when you buy.

Steel

NEW—BRUSH PATTERN DESIGN FOR THOMAS PRE-COATED STEEL

Here's a **brand new** addition to Thomas Strip Division's wide range of pre-coated and pattern designed finishes for decorative applications.

Called "Brush Pattern Design," this new Thomas Strip specialty reduces finishing costs, enhances sales appeal through its deep, lustrous, textured and buffed surface—offers products attractive "plus" that influences buying decision, moves items off the shelf.

"Brush Pattern Design" is cold-rolled strip electroplated with copper, brass, nickel or zinc coating, buffed to soft highlighted finish, protected by clear lacquer.

New Thomas Strip technique produces Brush Pattern Design Strip with uniform, nontarnishing plated coating across entire surface. Fabricates easily, without distortion of pattern finish.

Reduce your product's finishing costs, improve its appearance with Thomas Brush Pattern Design. Thomas experience, design help is yours for the asking. Call or write.

THOMAS STRIP DIVISION
PITTSBURGH STEEL COMPANY
Grant Building · Pittsburgh 30, Pennsylvania

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NSF builds "window to space" on Arizona mountain-top

PHOENIX, ARIZ. — The first major American observatory since Mt Palomar was completed some 30 years ago is now taking shape at Kitt Peak, Ariz. It will have a variety of equipment for astronomical research, including the world's largest solar telescope and 5 stellar telescopes. Eventually there will also be a 50-in. telescope, orbiting in cycle with the stars 22,000 mi in space.

Some small optical instruments of up to 36 in. are already in service. But right now the dominating effort is installation of the 300-ft focal-length solar telescope, which will focus a 3-ft-dia image of the sun.

It's being housed in 500-ft tunnel-like building, three-fifths of whose bulk is bored into solid rock. The remaining 200 ft extends above ground, resting on a 110-ft concrete pier with 4-ft-thick walls of reinforced concrete narrowing to 3 ft near the top. The structure is sheathed with watercooled copper panels.

Stability is a major problem with the tower. The pier is designed so it will move no more than 0.001 in. in a 35-mph wind. The tower and telescope tube will be painted white as insurance against heat.

A flat mirror, 80 in. dia, will be installed at top of the telescope as a heliostat to track the sun's path. Sunlight striking it will be reflected to a 60-in. underground concave mirror 480 ft away. From this point, the sunlight will bounce back up the tunnel 280 ft to a 48-in. mirror, which directs it to an underground observing room. Here the sun's image will appear as a 34-in.-dia disk.

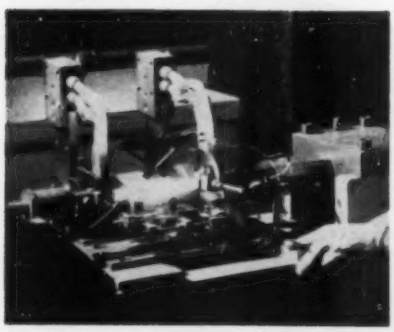
The large mirror at top will weigh about 2 tons and be hoisted into position on a narrow-gage railroad inside the tube. Grinding and polishing the telescope lens is underway at the Univ of Arizona.

Financially supported by the National Science Foundation, the observatory will be operated by the Association of Universities for Research in Astronomy Inc. Participating schools are Yale, Harvard, Oklahoma State and the Universities of California, Chicago, Indiana and Wisconsin. ■

—Frank Giancelli, Phoenix Bureau

news continued on page 24

Short-time test for short-term strength of heated metals

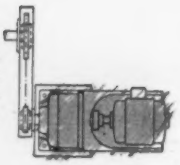


In a few seconds, this VST ("very short time") simulator, developed by Battelle Memorial Institute, electrically heats metal specimens to melting or some predetermined holding temperature. Simultaneously it subjects them to closely controlled stresses up to 400,000 psi. The equipment allows studying tensile strength, rapid heating, creep and relaxation at temperatures well above 2000 F, and is said to be particularly useful for evaluating short-term strength "built into" metals through cold working or heat treating. Stress, strain and temperature are recorded on remote equipment for later analysis.

Rocket helps man do a flying swan

This Buck Rogers-like gear has lifted a test engineer for Bell Aerosystems some 360 ft over ground at an altitude of 3 to 4 ft. His rocket belt has also flown the man to the top of 30-ft hills. Basically, the man-rocket system is a twin-jet hydrogen peroxide propulsion system mounted on a fiberglass corset molded to fit the back and hips of the operator. Metal control tubes, attached to the left rings, extend forward on each side. A control stick on one side permits the flier to change flight direction. His motorcycle-type hand throttle, mounted on the other tube, allows him to regulate rocket-thrust levels for controlling rate of climb and descent. The propulsion system is fully throttleable. When activated by pilot's controls, hydrogen peroxide is forced under pressure into a gas generator where it contacts a catalyst and decomposes into steam and oxygen. The gases escape through two rocket nozzles, giving the thrust (maximum levels undisclosed). Main thrust is directed toward ground, while jet deflectors provide thrust for yaw control.

MOTOGEARS Designed for bracket-mounting, foot-type NEMA motors of *any enclosure, any make.* Motor switching takes just minutes. No need to drain oil. Bracket assures accurate motor positioning. Book 2747.



GEARMOTORS Perfect choice for close quarters! Simple gear trains and flange-connected NEMA motor combine for exceptional compactness. Available in double, triple and quadruple reductions. Book 2747.

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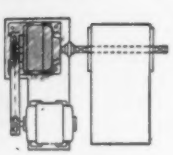
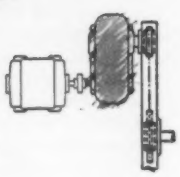
One of these seven

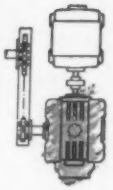
IN-LINE HELICAL GEAR SPEED REDUCERS Mount the motor *anywhere* . . . it needn't be direct-connected. And you save space with input and output shafts located on same planes. Available in double, triple and quadruple reductions. Book 2751.



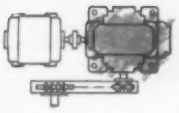
PARALLEL SHAFT SPEED REDUCERS 57 rugged, compact sizes! Built for continuous duty under the most punishing conditions. Easily withstand heavy shock loads, temporary overloads, moist or abrasive atmosphere. Available in iron and steel housings. Book 2719.



UNIVERSAL WORM GEAR SPEED REDUCERS
Multiple mounting flexibility! Simple, compact design packs maximum hp in a rugged housing. Initial cost is low, mounting space requirements slight. Made with 2½, 3, 3½ and 4-in. centers. Folder 2724.



WORM GEAR SPEED REDUCERS
Fan-cooled, compact, self-lubricated! Industry's *most complete* line for high-ratio speed reduction with right-angle takeoff. Single, double and helical worm gear combinations, with horizontal or vertical output shafts. Book 2824.



speed reducer line!

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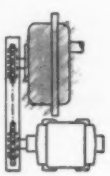
Full Layout Freedom! With Link-Belt's broad line to choose from, you can plan *any* speed reduction setup . . . *exactly* meet your requirements for ratio, space, shaft position, shock loading and other service factors. Link-Belt's seven basic types of speed reducers—each in a wide range of sizes and ratios—give you complete flexibility in drive layout.

There's another important advantage in calling on Link-Belt for your speed reduction needs. Link-Belt makes all related drive components—chains and sprockets, bearings, couplings—all dimensionally correlated with these reducers. This one-source service assures you of a smooth-working, perfectly matched set of equipment. No alignment problems . . . no need to exchange drawings with other suppliers.

See the Yellow Pages for your nearest Link-Belt office. Look under "Speed Reducers." Ask for any or all of the catalogs listed above.

LINK-BELT

SHAFT-MOUNTED SPEED REDUCERS Install easily without special tools . . . in angular, horizontal or vertical positions with tie-rod flange mounts or screw conveyor adapter. Off-the-shelf availability. Books 2618 and 2718.



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Britain checks migration of scientists to America

LONDON—British scientific authorities are making efforts to lure home scientists who have emigated to North America. The annual report of the Department of Scientific and Industrial Research for 1960, published here, details the success obtained so far.

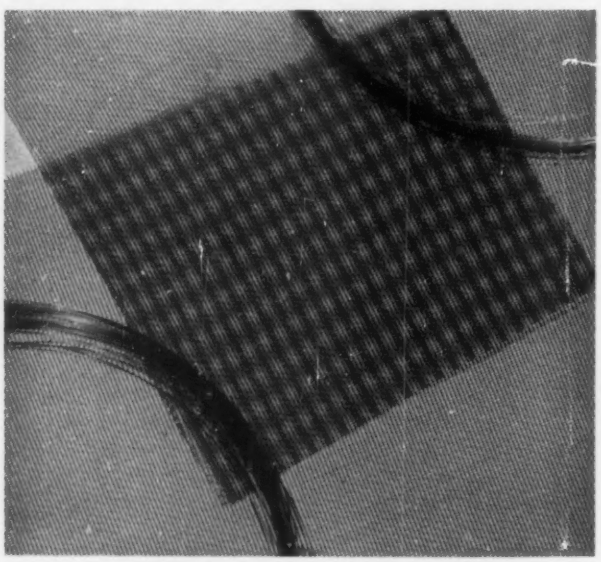
During 1959 and 1960, 20 scientists returned from North America to take up British government appointment and university research fellowships sponsored by DSIR. During 1961 there will be an advertising campaign to widen interest in the scheme, which was initiated by the UK Atomic Energy Authority two years ago.

Migration of the engineers and scientists to the US and Canada has been causing widespread alarm here (*PE*—Aug 22 '60). No sure figures on the number of expatriates exist, but some observers estimate that losses of PhD material to North America run as high as 25%. Particularly alarming is the loss of key individuals whose experience is irreplaceable and vital to UK atomic energy and space projects. ■

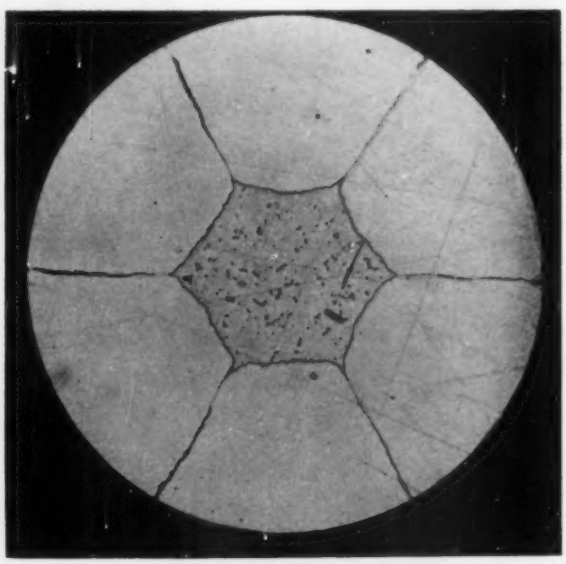
It flies—on wings of cloth

The wing of this test vehicle has a flexible, plastic-covered nylon substituting for the usual rigid metal surface. Under development at Ryan Aeronautical Co, the craft features a wing having a span of 39.4 ft and area of 555 sq ft. It's attached to a keel and V-shape leading edge, 28 ft long. Platform and 4-wheel landing gear are suspended beneath the wing. Ryan says the wing can be powered or unpowered and the craft can vary in size from small reconnaissance drones to large ones for recovering 50-ton rocket boosters. The wing has been tested in free flight and wind tunnels, from low subsonic velocities to speeds of Mach 4.9 and at altitudes up to 200,000 ft. Control system uses center-of-gravity shift instead of conventional displacement of control surfaces. The wing, foldable into a compact package, is inherently stable about all three axes because of the "pendulum effect." Ryan has a contract with NASA to study adaptability of the wing recovery of the first stage booster of Saturn.

Composite wire forms special screening



Wire woven-mesh belts, about four times finer than window screening, are now carrying paper pulp, water and residual acids in the continuous manufacture of paper. These belts —some 130 ft in circumference and about as wide as a 2-lane highway—of phosphor bronze or nickel-plated phosphor bronze—are subjected to water, acid, steam and pressure, and usually are replaced each week. Fort Wayne Metals and W S Tyler Co, Cleveland, in a joint development, are now marketing under the name of Tyflex a belt



of special composite wire that extends life a minimum of four times. Six stainless steel strands around a phosphor bronze core are drawn through diamond dies and annealed repeatedly. The soft-metal core squeezes down and bleeds into the space between the wire components to form wire as fine as 0.0045 in. (see photomicrograph.) This wire is woven into belts for the paper industry that have lasted as long as 70 days. The composite wire is being evaluated for other applications, including aircraft control cables.

"The grip that never slips!"

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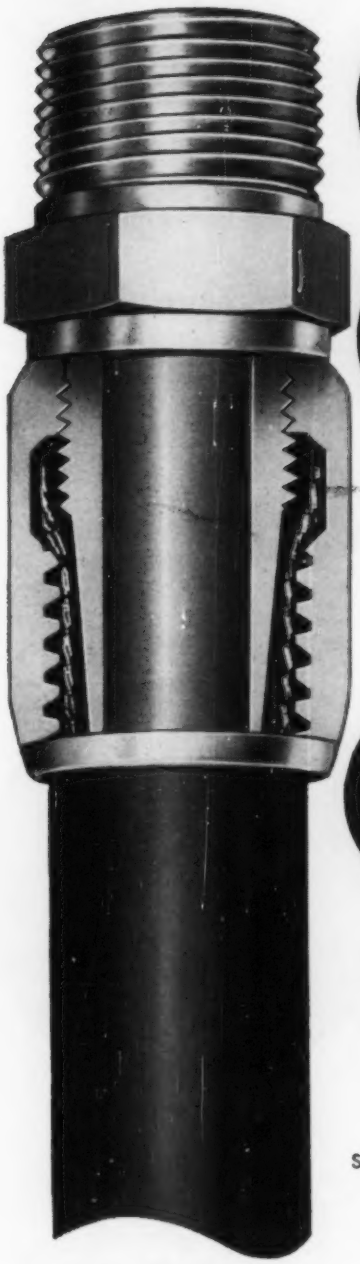
give you five big design features you want!



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fast replacement

full-line selection

positive "no-leak" seal

40% longer hose life

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Research proves non-skive hydraulic hose assemblies last 40% longer than skived assemblies. That means 40% less replacement cost! Here's why: the wire braid in Surgepruf's hydraulic hose is buried in rubber... stays buried in rubber. The result: a "super-seal" that literally fuses rubber to metal—prevents leaks.

Surgepruf's rugged hose meets SAE Hydraulic Standards' dimension, working pressure, and burst requirements—has wide temperature range—resists weather aging, abrasion, water, and oil. It's available in IDs from $\frac{3}{16}$" to 2".

Using Shur-Lock reusable couplings, these non-skive assemblies provide fastest on-the-job replacement. No special assembly tools are required.

IMPORTANT: Surgepruf's full line of interchangeable hose, reusable couplings, and adapters are always available from Alemite's many sales outlets coast-to-coast. Get full information and detailed specifications today... send for free Surgepruf catalog No. 40-25, today!

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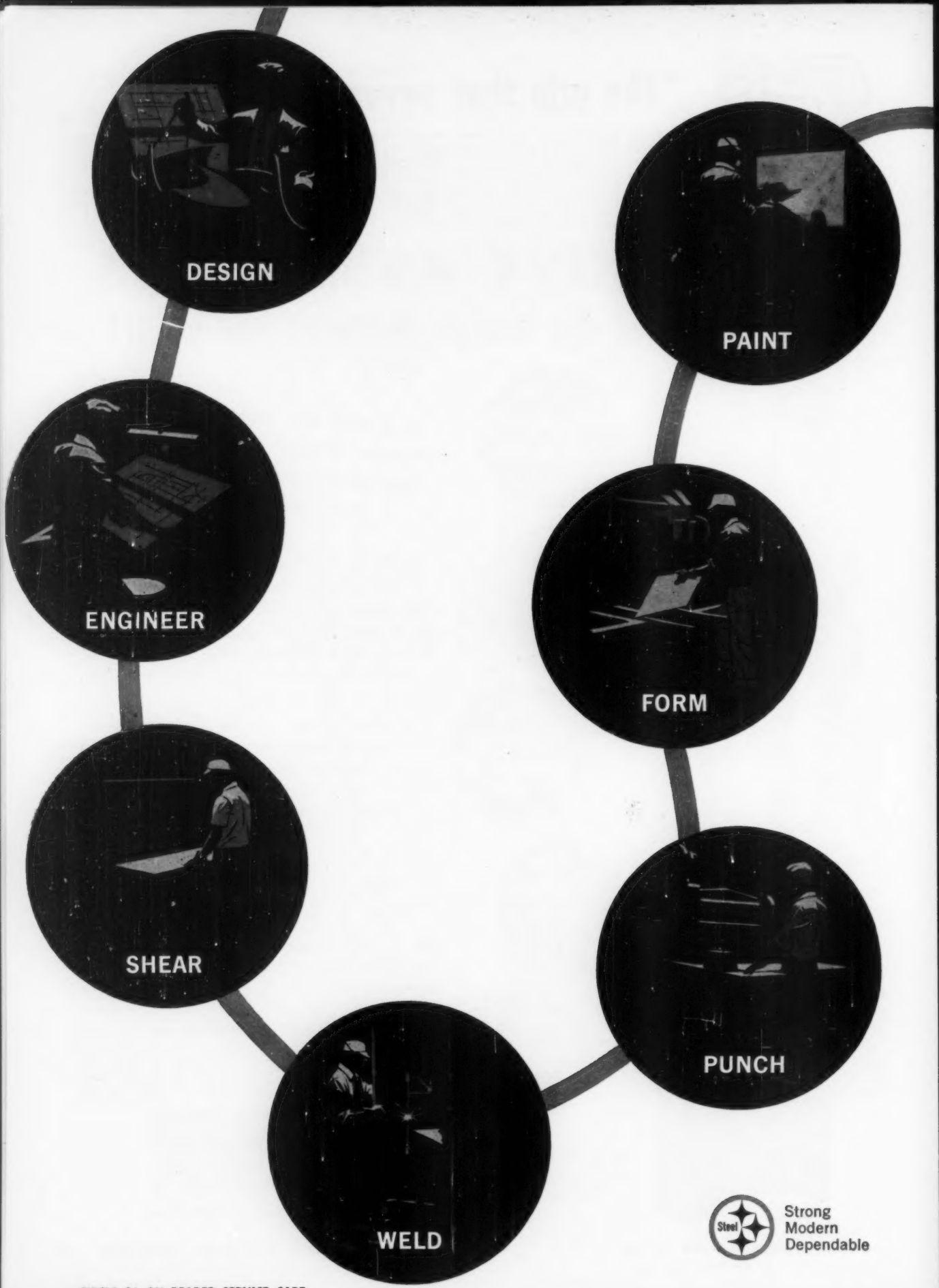

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Republic saves you money on sheet metal fabrication, every step of the way

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A tour of Berger's efficient plant points up another factor that keeps costs at rock bottom. Scientifically planned material flow is combined with straight-through production lines to eliminate excessive handling, speed fabrication, assembly, and delivery.

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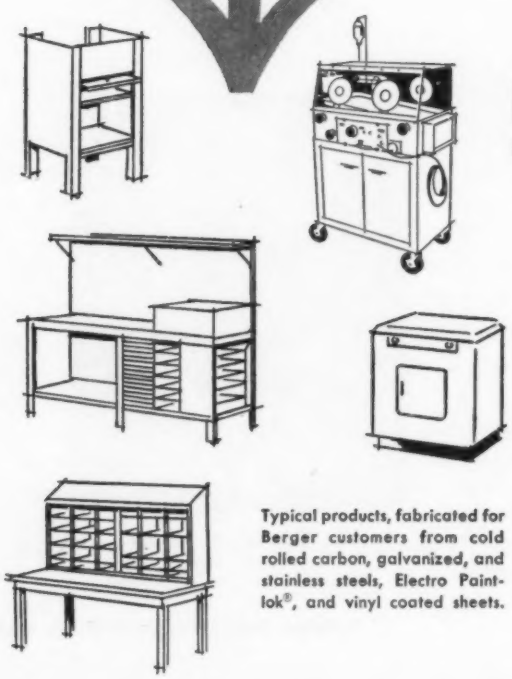

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POINTS OF VIEW

THE QUESTION: *What technical problems need*

R C Durstein
Product manager, titanium
Crucible Steel Co of America

"Excess capacity has plagued . . .
the titanium industry since 1957. Titanium's cost is the major deterrent to developing markets to use this extra production capability. It is therefore understandable that the most welcome technical breakthrough would involve lowering of production costs. Attention is always focused on raw-material costs because titanium sponge sells for about $1.60 per pound and it is not unusual for sponge costs to account for over 50% of the cost of certain mill products. Therefore; if a cheaper method of making sponge can be developed, it would result in substantially lower prices for sheets, bars, billets, etc, and a consequent rise in tonnage sales of all these products.

"If technological advances can be accomplished, more cost reductions could be made in the processing of the metal also. The most critical area is the production of sheets with minimum variation in thickness for individual customer requirements. These are now manufactured, for the most part, on sheet mills which were designed for production of steel. If the technical problems can be solved, a mill specifically designed for titanium and refractory metals could be built. Costs would be lowered quite significantly.

"There are other areas where technological advancement is needed. The joining of titanium to other metals presents a problem to fabricators. If a simple means were found for joining titanium to stainless steel, carbon steel and aluminum, a real roadblock to its increased usage would be removed. Technical problems currently prohibit the production of reasonably priced titanium castings. The ability to produce relatively inexpensive castings would help open markets for other mill products."

The tarnishing problem . . .
is the greatest deterrent to increased sales of copper. Surveys have shown that vast new markets for the red metal and its alloys would open up if technologists could come through with a 'stainless' copper or with a clear coating for copper and brass products that would withstand abrasion and atmospheric deterioration. These markets would be primarily in the building, hardware goods, appliance, and furniture-manufacturing industries.

"The Copper Products Development Assn is attacking the tarnish problem from a number of angles, including the use of both organic and inorganic coatings for protective purposes and the selective oxidation of minor constituents in alloys to form integral and continuous films in micron thicknesses. Preliminary results are hopeful, and it seems fairly certain that copper and copper-base products vastly superior to present ones in respect to tarnish resistance will be forthcoming. Two other problems of moment pertain to the joining of copper and copper alloys below the soft-annealing temperature and the development of an alloy that retains its strength at high temperatures. These, the association plans to attack in the near future."

Dr Charles H Moore
Technical director
Copper Products Development Assn

solving in the primary-metals industry?

R T Myer
Metallurgical manager
Kaiser Aluminum & Chemical Corp

The need for greater standardization . . .
in mill product specifications with respect to alloys, thicknesses, sizes, tolerances and finishes is one of the most important technical problems in the aluminum industry. Adequate solution to this problem would benefit both user and producer. From long experience, both design engineers and production men think in terms of standard items when it comes to steel. But with aluminum, there has been a habit of thinking in terms of custom items, in large part probably because aluminum until fairly recent years was used to a major extent for specialty purposes.

"Today, however, aluminum has become a major metal and must emerge from the custom type of mill production as the trend grows toward using major quantities in automobiles, housing and construction, ordnance equipment, and cans. Such applications make possible longer-run production of various standard items. Obviously such long runs increase the producer's mill efficiency.

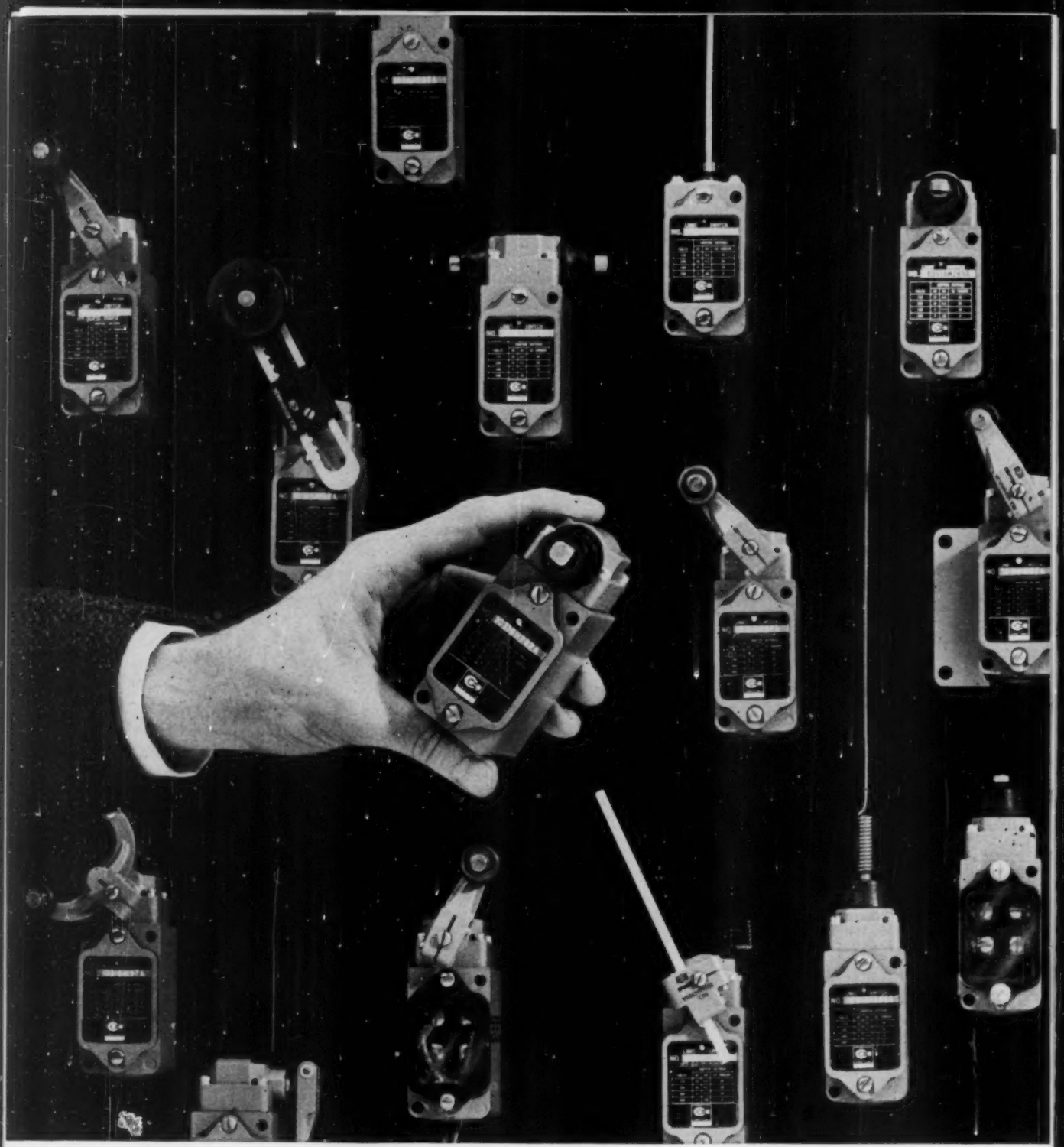
"This question of standardization is a technical problem, as well as commercial. It can be solved only through the effective cooperation of producers and users, with assistance from the various specification code committees and authorities. Within the aluminum industry a start has been made by the Technical Committee of the Aluminum Association, but there is much work to be done."

"Improved fabrication techniques . . .
are needed to produce beryllium shapes with greater economy of material by hot-processing processes or by conventional forming equipment. For the intermediate position, the industry must prepare to offer a standard line of mill products in the form of bar, rod, sheet and castings with guaranteed properties and tolerances. And, finally, the long-term growth will depend on development of techniques for generating improved ductility.

"Until recently, all beryllium metal parts were made by machining solid blocks of hot-pressed beryllium powder, with obvious limited efficiency of utilization of material. Recent work shows great promise in achieving the desired parts of hot-pressing powder directly to shape in contoured dies, by forging encased powder or hot-pressed block, and by extrusion. For the short-range picture, improvements and refinements in casting, resulting in crack-free and fine-grained structures, are under development, leading to a type of material from which standard mill products will be forthcoming, including castings.

"The greatest impetus to a constantly growing, healthy beryllium metal industry over the long term will be the discovery of processes for producing a ductile metal, following the evolution of ductile titanium and zirconium, which are also hexagonal metals. This may come by reducing impurities, presumably specific ones, to levels substantially lower than now in commercial existence, or possibly by alloying to stabilize the body-centered cubic phase which exists over a narrow temperature range below the melting point."

Dr B Kopelman
Director of research
The Beryllium Corporation

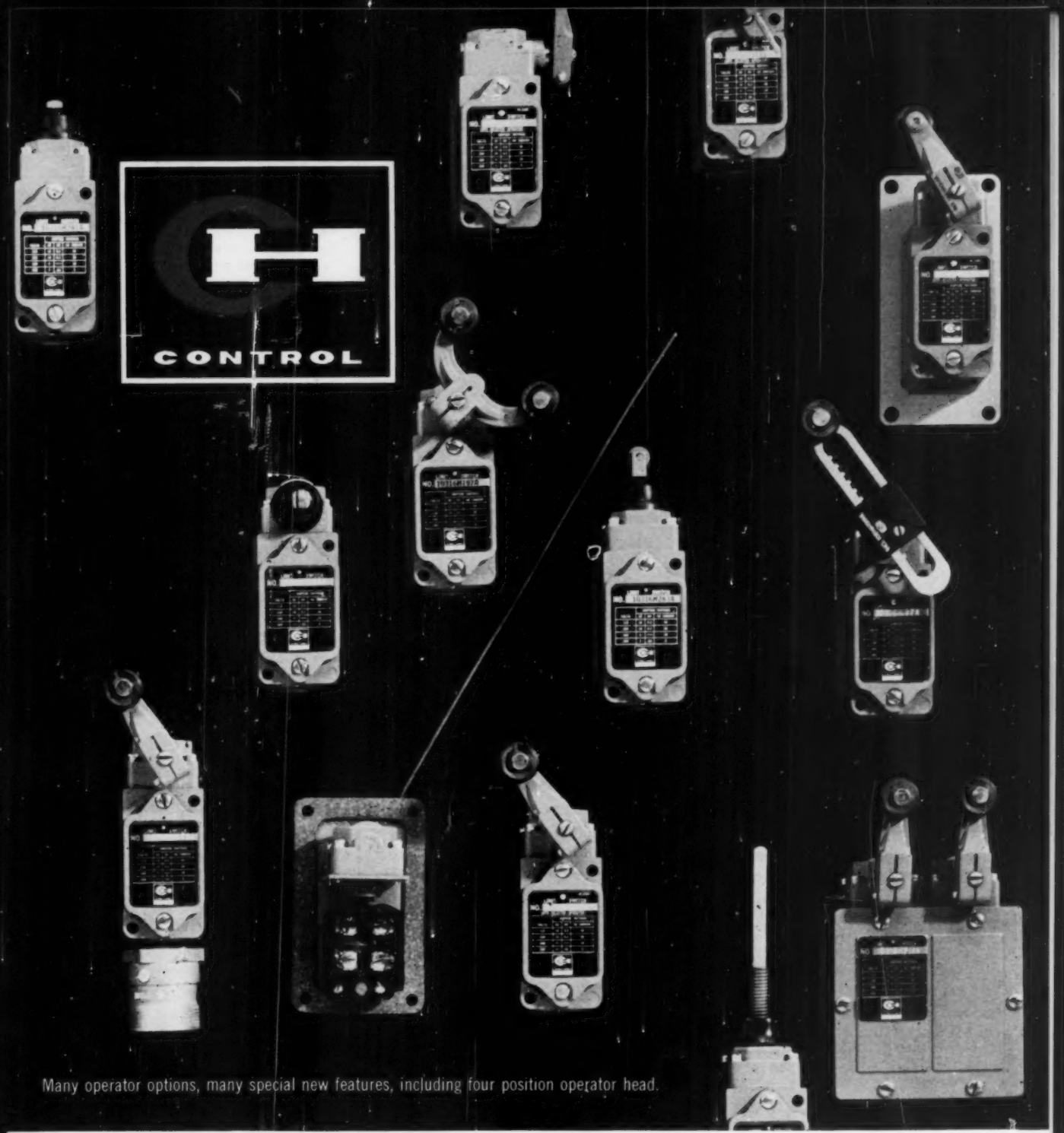


What's your problem? If you can solve it with a

New Cutler-Hammer operator options provide top flexibility... world's best oiltight limit switch

For any use, anywhere, in any position . . . you just can't buy a more reliable, longer-life switch. No other switch is sealed more effectively . . . effectiveness we've proved under test conditions so rugged they will never be equaled in actual service. Even the silver-to-silver contacts are visible for quick inspection. For full details on this complete new line, write for Pub. ED-145-L249.

For any electrical control problem, contact your local Cutler-Hammer sales office or distributor. They'll supply you with the finest electrical components, the finest service and technical help.



Many operator options, many special new features, including four position operator head.

limit switch, your best answer's here!

WHAT'S NEW? ASK...

CUTLER-HAMMER

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CONTROL

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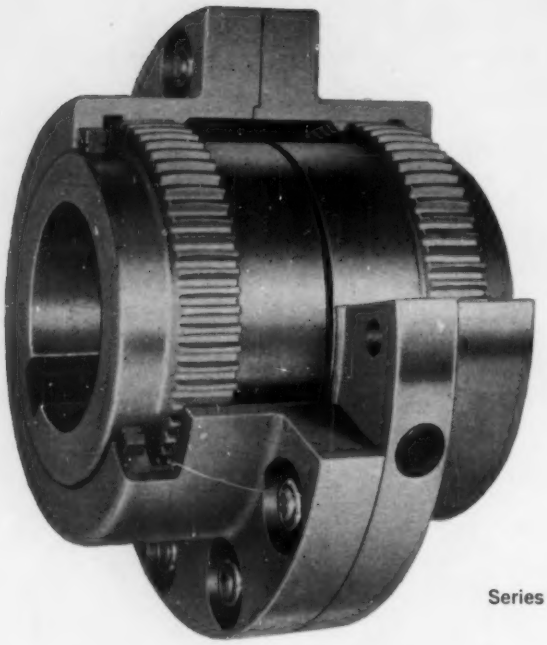

Series "A"

Forged steel, lube-tight gear couplings

Both hubs and sleeves of these rugged Waldron standard "Series A" couplings are made of forged steel, and the two one-piece cover sleeves function as a single unit. There are no flexible parts to bend or break. At the same time, the grease-tight, patented Walflex seal is placed where the pressure is least, to prevent lubrication problems. You can get prompt delivery of any of the sizes listed below. Write for bulletin S-1000.

Size and nominal bore	Max. over bore	HP/100 rpm	Max. rpm
1¼A	1⅜	6	12,000
2A	2⅛	21	10,000
2½A	2⅝	45	9,000
3A	3⅜	87	7,500
3½A	3¾	150	6,500
4A	4¼	225	6,000
4½A	4¾	365	5,300
5A	5½	525	4,700
5½A	6	717	4,300
6A	6⅝	962	4,000
7A	7½	1137	3,300

WALDRON-HARTIG, Box 791, New Brunswick, N. J.
a division of Midland-Ross Corporation

WALDRON
Makes it easy to pick the right

Couplings

32 CIRCLE 32 ON READER SERVICE CARD

READER TO EDITOR

For PE and VE—kudos

To the Editor:

I wish to compliment you on the special article you had in PRODUCT ENGINEERING (May 22) on Value and Value Engineering. It isn't often that anyone considers "Value" important enough to write more than a few paragraphs, when we know that it is as important as "quality."

Our management was so impressed by this article that a decision was made to have it distributed to all key personnel.

—F W YAZOMBEK, *staff engineer*
Value Analysis
Kellogg Switchboard & Supply Co
Chicago

To the Editor:

Your recent article on "Value . . . the emerging emphasis in design" was the most comprehensive article on this subject I have seen published. Value Engineering and its associated terms are coming into widespread use, with little idea as to what types of functions they involve. Your article has brought these terms into focus. . .

—J B TOOMEY, *president*
Value Engineering Co
Alexandria, Va

• This article has been reprinted as a 16-page folder in response to numerous requests. It is available for $23 per 100 copies; single copies, 25¢ ea.—Ed.

To the Editor:

I cannot resist commenting on the May 1 issue, p 39. The editorial "Rut of Complacency" is very good. You have surpassed yourself, if such a thing is possible. It is refreshing, as well as something of a moral relief, to see somebody who has the guts to get up and publicize such things that need to be aired. I hope I will not offend you by quoting from a contemporary of yours who also writes pretty good editorials. His latest one is "Anyone for Advice? Why keep it to yourself?" I quote from the closing paragraphs: "But what pride silence? Probably an extra push ahead, maybe a foul-up later. But under today's mores, it is the thing. But since today's sheep follow such a path, maybe it would be a good idea to be old-fashioned and speak your piece—when you have the facts, the enthusiasm, and the guts." That's from Tom Campbell, editor-in-chief, *The Iron Age*, May 11, 1961.

Also, the Value Analysis article is very timely indeed. We have been experimenting with quality control for about two years now. Before that, we did not have anything in this line at all. We had relied, as you state it, on the ability and incentive of the designer to manage it. An increasingly intelligent consumer market, coupled with an increasingly aggressive competition, is getting us into serious financial trouble. We are attempting to diversify, and consideration of same is getting us into just the kind of thing that you discuss so well in your Value Analysis article.

—CARL G EICHENBERGER
Troy, N Y

Wild Old Patents

To the Editor:

In your department "Interesting to Note" you published (in your May 22 issue, p 3) one of the screwball ideas patented around 1896. Legend has it that, in this period of our history, the Treasury had been depleted and a policy of "patent anything" was adopted. The only requirements seemed to be: Does he have the necessary fees?

If I am not mistaken, your description of the gadget is incorrect. Either this gadget, or one very similar, was intended to "salute" the ladies in cold weather, while the wearer kept his hands warmly cuddled in his pockets. The way the gadget worked was: The wearer nodded his head slightly, which tripped a weight-activated mechanism. Thereupon, the hat rose slightly, described one complete rotation, and flopped back down on the noggin of the wearer.

As you are probably aware, there were some really hilarious screwball inventions patented in the 1896 era, but which censorship would prevent your publishing.

—R W Pecaut
Equipment superintendent
Ohio Turnpike Commission, Berea, Ohio

COMING EVENTS

JUNE

18-23 . . . . American Institute of Electrical Engineers, Spring General Meeting, Cornell Univ, Ithaca, NY

25-30 . . . . American Society for Testing Materials, 64th Annual Meeting Chalafonte-Haddon Hall, Atlantic City, NJ

26-30 . . . . American Institute of Electrical Engineers Conference on Concepts and Design in Aerospace Electricity, Benjamin Franklin Hotel, Philadelphia

26-28 . . . . American Society of Heating, Refrigerating and Air Conditioning Engineers, Annual Meeting, Denver-Hilton Hotel, Denver

28-30 . . . . Institute of Radio Engineers, ASME, AIEE, ISA, AIChE, 2nd Joint Automatic Control Conference, University of Colorado, Boulder

JULY

9-14 . . . . Instrument Society of America, IFME, AIEE, IRE, 4th International Conference on Bio-Medical Electronics & 14th Conference on Electronic Techniques in Medicine & Biology, Waldorf-Astoria Hotel, NYC

18-20 . . . . Western Plant Maintenance and Engineering Conference and Show, Pan Pacific Auditorium, Los Angeles

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.

What do you want a Float to do?

Nicholson Floats are your dependable, efficient answer

...and here's why!

Light enough for use as buoyancy mediums, or heavy enough for use in high pressure process vessels and as fluid containers or pressure chambers, Nicholson floats are die-formed . . . not spun, laminated or electro-deposited. Precision-welded for rugged durability at working pressures up to 2500 lbs. Annealed to prevent cracking. Uniformly thick walls with butt-welded seams. Spherical, elliptical or cylindrical. *Steel Floats:* chromium, cadmium, copper plated. Also unplated, with sandblast or pickled finish. Stainless Steel and Monel Floats: rough buffed or polished with smooth, highly-finished welds.

This Coupon Brings You Informative Bulletin On Floats

Bulletin 753 contains facts on steel, stainless steel and monel floats, information on float connections, tables showing weight, buoyancy and collapsing pressure for spherical floats for all gauges . . . also volume and buoyancy data. Fill in and mail this coupon for your copy.

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W. H. NICHOLSON and COMPANY
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The Westinghouse man with the motors brings you—

New Class B Insulation to give you 15% more horsepower on totally-enclosed Life-Line motors

Now Class "B" Insulation replaces Class "A" *as standard* on totally-enclosed 1-250 hp Life-Line a-c motors giving you these advantages:

Added capacity . . . Operation at 15% over nameplate rating without reduction in motor life.

Longer life . . . 80% to 100% longer life at rated loads than motors with Class "A" Insulation.

This newly designed motor is engineered to give top performance in a wide range of applications. On-the-line experience in the steel industry, where maximum reliability is essential, has proved its higher output, longer life and lower maintenance under the toughest conditions.

For the ultimate in protection specify Guardistor* on all Westinghouse motors. This exclusive built-in static motor protection allows the use of maximum horsepower over long periods with no danger of motor burnout.† For additional information ask for booklet B-7876-A.

Your Westinghouse sales engineer can supply you with complete details on these money-saving motors. Call him for full information on how they can fit into your production scheme. Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania.

You can be sure . . . if it's Westinghouse.

*Trademark

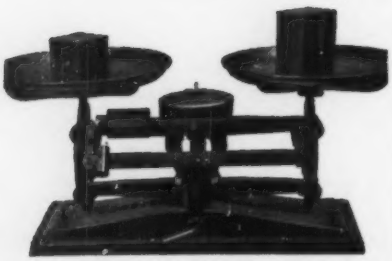
Westinghouse

†Warranty: Westinghouse GUARDISTOR MOTORS on frames 182-445 inclusive are guaranteed for one year against burnouts due to overheating resulting from: overload, locked rotor, blocked ventilation, bearing seizure, single phasing, unusual duty cycle, high ambient, or voltage unbalance, providing the Guardistor elements are connected in a control circuit so that the motor is removed from the power source in the event of over-temperature.

J-22170

KENNERTIUM*

...a new alloy 50% heavier than lead



Both blocks on the scales weigh the same. However, the lead block on the right occupies 50% more space than the cube of Kennertium at the left.

Usually, when high density or concentrated mass is desirable . . . small volume is, too. Ballasts and counterweights for missiles and jet aircraft, for example, must often fit very small areas. For these and many similar applications, Kennertium—a special blending of tungsten and other elements—is now being used.

In the above photograph, the block on the left is Kennertium . . . the one on the right is lead. For equal *volume*, Kennertium provides 50% more weight than lead. The high specific gravity of the material makes it particularly suitable for counterweights on the wings and empennage of aircraft (below right).

Used as a radiation shielding material, Kennertium (containing over 90% tungsten) is more effective than other materials.

Still another use is for high rotational inertia . . . such applications as gyroscopic rotors and torsional vibration dampeners.

The piece shown above left indicates the excellent machinability of Kennertium. It also has high malleability (10% elongation) at high tensile strength (115,000 psi). For more information, send for Kennertium Properties Booklet. KENNAMETAL, INC., Department PE, Latrobe, Pennsylvania.

*Trademark 34227

INDUSTRY AND KENNAMETAL ...Partners in Progress

FOR YOUR INFORMATION (personal)

When Junior goes adrafting

Here's one you'll steal from the kids. It's a drafting set, complete with light-up box, sliderule, T-square, French curve, protractor, tracing and blueprint paper, drafting pencils and even a pencil sharpener—all for $9.95. For junior, there's an instruction booklet, too, with pointers on lettering, sketches, and layout. It tells how to use the sliderule and how to design gearing; also, it has a brief glossary. Lakeside Industries, 3200 Snelling Ave, Minneapolis 6.

More help from bats

Following its studies of homing pigeons as sensing and guiding mechanisms for missiles and bacteria for improving the efficiency of storage batteries (*PE—Nov 14 '60, p 8*), Navy is now investigating bats in the hope of improving radar-sonar systems.

The *Noctilio leporinus* bat, says Navy, has a system for locating and catching fish that can teach us quite a bit. Apparently, this particular species locates fish targets while flying over water and sending out ultrasonic pulse trains. It has also been observed that these bats frequently raise their pulse emission rate just before dipping, in much the same manner that insect-catching bats do.

Prof D. R. Griffin of Harvard, making the study for Office of Naval Research, uses an ultrasonic detector and a small tape recorder to obtain information about the repetition rate of the bat's pulse emissions while fishing; and synchronizes the tape with electronic flash photographs. The tapes are new being analyzed, and additional data are to be collected.

Midget record?

Claiming to be "the world's smallest tape recorder," this Viennese *Memo-Cord* weighs less than 1 lb, has 3 transistors and transistorized amplifier, measures about 4½ by 3¾ by 1½ in. It's powered by one 9-volt and one 1.5-volt battery, has a 5-track recording system (12 minutes per track), and is designed for one-hand operation.

V Stuzzi & Co, Vienna XV, Schaettermayergasse 30 is the manufacturer; expects to have limited quantities on the US market later this year. Price: about $70. —ARG

first in silicones

Dow Corning

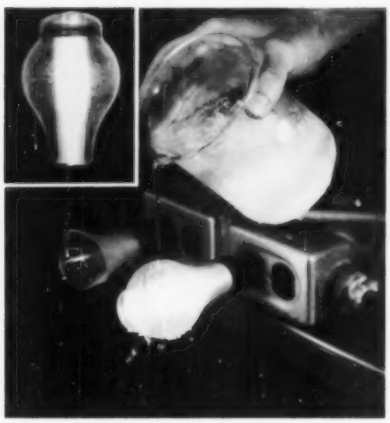
SILICONE NEWS

for design and development engineers · No. 83

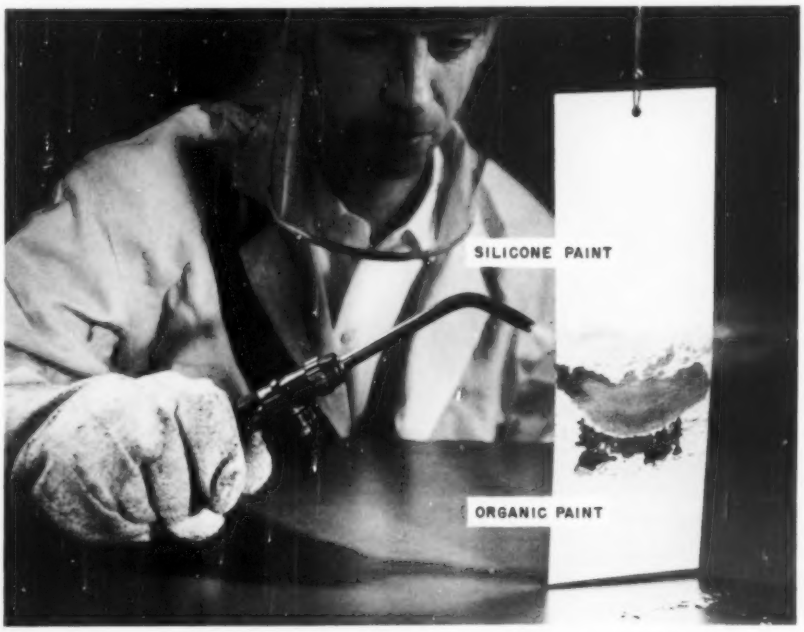
SHATTERPROOFED WITH SILICONES

One of the most common safety hazards — exploding light bulbs — has been overcome in a new incandescent lamp through the use of silicone adhesives and glass yarns.

Developed and marketed by Duro-Test Corporation, North Bergen, New Jersey, the new lamp — named "Flamescent" — is truly shatterproof. It can be dropped onto a hard surface without exploding into a shower of glass. While in use (and hot) it can be dipped in ice water without danger of flying glass fragments.



Unique application of new *and* old materials gives the lamp this safety-glass ruggedness. The bulb consists of a glass shape wound with *(Cont. pg. 2)*



New Finish For Hot Spots

Metal products of all descriptions can now be made to stay new looking longer even when subjected to hot operating temperatures or to the deteriorating effects of weathering. How? By using protective coatings and finishes formulated with Dow Corning silicone resins.

Colored product finishes based on these semi-inorganic resins won't crack or blister even up to temperatures as high as 600 F. Gloss and color are retained even though constantly exposed to sunlight or corrosive atmospheres. Result — longer life, and increased customer satisfaction.

New silicone-alkyd baking enamels combine ease of application with flexibility and toughness. Using these enamels, it's frequently practical to paint-before-forming metal parts. Baking cycles are consistent with standard painting practices.

Full range of colors, too. Silicone-based paints can be pigmented almost any hue.

Available now from many paint manufacturers, silicone-based paints could help make important changes in your quality and profit picture. For more information and names of suppliers, circle . . **No. 242**

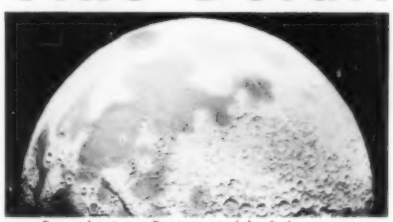
Paint based on new Dow Corning resin takes a 180° bend on a ¼" mandrel without crazing, checking, or peeling.

Reproduces Fine Detail

The making of what are believed to be the most accurate models of the moon in existence today was given a big boost by Silastic® RTV, the fluid silicone rubber that cures at room temperature.

By pouring Silastic RTV over his original, painstakingly constructed model, Mr. William Benton, "the moon man", obtained flexible and dimensionally stable molds that perfectly duplicate the extremely fine details of the original. Polyester resins are cast in the RTV molds to make more of these accurate moon models.

Silastic RTV is easy to use. Simply mix it with a catalyst and pour. The mix flows freely, filling every hairline. After a few



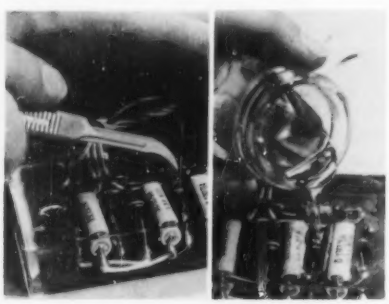
Reproduction: Benton model of the moon

hours at *room temperature*, you have a flexible silicone rubber mold that strips readily. You're ready to start casting!

Flexible molds for producing prototype parts in plaster, plastics, waxes or low melt alloys are quick and inexpensive with Silastic RTV. Circle . . . . . **No. 241**

WANTED: CREATIVE ENGINEERS

. . . to investigate a unique new silicone resin that cures to form a tough, transparent mass. Named Sylgard® 182, this new solventless silicone resin is supplied as an almost colorless liquid. After blending with its curing agent, it's a simple matter to pour it in place.



Even in totally confined enclosures, Sylgard 182 cures to a flexible and transparent material having outstanding dielectric properties and good moisture resistance from —100 to 400 F. On the Shore A Scale, hardness of Sylgard 182 is approximately 40; elongation is in the range of 100%. Tensile strength is in the range of 800 to 1000 psi.

Curing time for Sylgard 182 Resin can be varied by changing the curing temperature. At 150 C, it cures in 15 minutes; at 65 C, four hours; at 25 C, three days. Neither the resin nor its curing agent is toxic to the skin. No toxic fumes are given off during mixing or curing.

⇦ Electronic components and circuits encapsulated in Sylgard 182 Resin are clearly visible, simplifying replacement or repair procedures. The cured resin can be cut away with a sharp knife to permit repair or replacement of defective components. New resin poured over the repaired area adheres to the existing cured material, restoring the encapsulant to the original condition.

Keep in mind that while this new material exhibits some rubber-like properties, it is a solventless silicone resin, not a rubber. For more data and information about Sylgard 182, circle . . . . . ***No. 243***

new literature on silicones

Silicones in Appliances can give that extra edge for extra sales. This colorful booklet tells where and how silicones are being designed into appliances to give more efficient and reliable performance. Illustrations show how planning around silicones can make good products better. ***No. 245***

Space Age Silicones are described in thirty typical application stories. Utilization of silicone compounds, fluids, lubricants, protective coatings, rubbers, resins, potting materials and sealants are illustrated for your consideration. This valuable brochure offers solutions to many problems encountered in designing space age aircraft and ground support equipment. ***No. 246***

You And The Silicones — a 30-minute, full color movie lets you see silicones in action. It's an all-encompassing, dramatic documentation of designers' adaptations of these versatile engineering materials in different applications. For information about arranging for a free showing, request . . . . . ***No. 247***

LIGHT BULB *(Continued)*

Fiberglas yarn. The glass and yarn are bonded into a single unit with a rubbery Dow Corning silicone adhesive. Several materials were tested but only the silicone adhesive remained transparent and resilient despite long, continuous exposure to the heat of the lamp.

While the Flamescent derives its name from the warm, flame-like glow it casts, its lumen output is actually higher than that of any other processed bulb. It is a glareless bulb and lasts at least 3 times longer than conventional lamps..

Available in standard sizes, the Flamescent with its weatherproof features is ideal for yard and outside display lighting. Duro-Test also recommends the new bulb for use in all types of industrial and commercial fixtures where the bulb may come in contact with flying sparks, welding slag, hot solder, water, and many other attacking conditions. ***No. 244***

Dow Corning Corporation, Dept. 5218, Midland, Michigan
Please send me: 241 242 243 244 245 246 247

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Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

Anything you can do with a drafting machine you can do almost as well with a T-square, triangle and protractor. It just takes a *lot* longer and it's a *lot* harder. That's why so few drawing boards these days are seen "sans-machine."

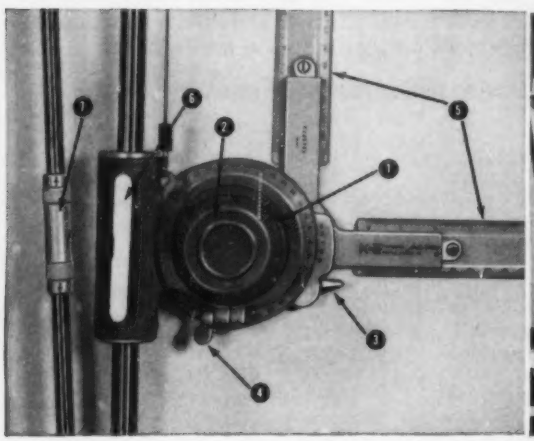
Every board – and draftsman behind it – has slightly different requirements. This is why there are PARAGON® Drafting Machines by K&E in a variety of tested styles. Just take your pick:

Whatever your angle . . .

The PARAGON AUTO-FLOW® Drafting Machine is tops – by far the most versatile drafting machine to come along in years. A track-type machine with a wealth of work-saving features, the AUTO-FLOW can simplify your whole drafting operation. The board angle *you* find most convenient will suit the AUTO-FLOW to a "T." And no irksome counterbalance weights or friction brakes are necessary. A quick adjustment of a tension spring wheel puts the AUTO-FLOW in perfect balance – vertically, or anywhere down to the horizontal. The AUTO-FLOW's scales can be moved quickly and locked firmly into *any* position on the board. Both horizontal and vertical motion brakes are designed for rapid, one-hand operation. Smooth, *full-board* action lets you draw straight lines the entire length and width of the board in one continuous motion – something it's impossible to do with conventional machines. And – the *piece de resistance* – the AUTO-FLOW's superbly functional designs puts *all* controls conveniently on, or adjacent to the control head for the easiest operation ever. This engineered control system considerably reduces the number of arm and hand motions needed to produce a finished drawing.

Taking a page out of school . . .

A lot of firms employ chalkboards for group work, demonstration, rough planning, and other forms of "communal" drafting activity. If you've got such a board around your shop, we've got just the machine to fit it. Called the "Chalkboard" AUTO-FLOW this is essentially an AUTO-FLOW with elongated horizontal and vertical tracks and special mounting brackets. Whatever the length or height of your chalkboard, there's a Chalkboard AUTO-FLOW to accommodate it.



1. Full 360° indexing with automatic 15° stops, released at a touch, 2. Contour-designed control knob to match shape and motions of the hand, 3. Thumb-release to set in-between angles, 4. Base-line release – located near protractor head for fastest operation, 5. Easily-adjusted, interchangeable scales, 6. Conveniently placed finger-tip brake control to lock or release vertical position, 7. Convenient horizontal motion brake for one-hand operation, sitting or standing.

An old dog with new tricks . . .

If you prefer the conventional, "elbow-armed" drafting machine, the PARAGON standard is just your dish. You'll find plenty of refinements here, too. This is *one* "elbow-armed" machine that won't creep or crawl on the board. Just a twist of a thumb screw adjusts for perfect arm balance at any board angle up to 10°. The arms themselves *never* need adjusting. Tension bands are factory-set for years of use. Scales always lie snug and flat on the board and both arms twist freely in either direction. They can be lifted over objects on the board and returned to the same setting with ease. Baselines can be changed instantly, too. A convenient release lets you establish a new baseline in seconds, while maintaining your "0" setting on the protractor. And the PARAGON standard has essentially the same engineered control head that so many swear by on the PARAGON AUTO-FLOW – the biggest time-saver in drafting since paper.

For the sometime user . . .

Maybe you're a design engineer, a chief draftsman, an ex-draftsman "keeping his hand in," or any one of many having only occasional need for a drafting machine. If so, the PARAGON Jr.® (shown below) is your mate. Originally designed for desk use by students, the PARAGON Jr. is ideal for the "part-time" draftsman. Patterned after the PARAGON standard, this compact drafting machine offers all the important features found in its full-sized counterpart, *plus* the convenience of "tuck-away" dimensions. Its combination mounting bracket permits temporary or permanent mounting on almost any desk, board, or table. It will operate efficiently at any board angle up to 25° and will accept any scales with standard chuck plates. Its engineered control head has full 360° indexing with automatic 15° stops, a convenient lock-lever for intermediate settings, and a rapid release for full 360° base-line adjustment while retaining "0" indexing.

And that's the lot – a PARAGON, we hope, for everyone. If the ease and speed of "feather-touch" drafting has a place in your operation, simply fill out and mail the coupon below and we'll show you how the PARAGON of your choice delivers it – like no other drafting machine can.

KEUFFEL & ESSER CO., Dept. PD-6 Hoboken, N. J.

Gentlemen:

Please send me complete information on the K&E PARAGON Drafting Machine(s) indicated:

- ☐ K&E PARAGON AUTO-FLOW Drafting Machine
- ☐ K&E PARAGON standard Drafting Machine
- ☐ K&E PARAGON Chalkboard AUTO-FLOW Drafting Machine
- ☐ K&E PARAGON Jr. Drafting Machine

Name & Address: _____

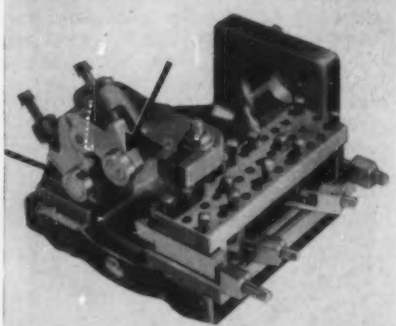
Company & Title: _____ 4065

McGILL® CAMROL® BEARINGS

are proven performers—with cost and assembly advantages

McGILL CAMROL bearings have rolled up an unequalled 25-year history of high performance and dependability — with the cost savings of standard bearings over built up shaft and roller units. They eliminate the time-consuming intricacies of procurement and assembly of parts for improvised bolt, bearing and washer followers. You, too, can rely on the designed-in ability of CAMROL bearings to accept intermittent shock and fluctuating heavy loading coincident to cam action, track or guide and support applications. CAMROL bearings are built for stock in roller diameters from ½" to 4" in the CF series with integral stud and the CYR series for shaft mounting. Both types are available with or without positive, integral seals for retention of prelubrication and protection against contaminants. Following are typical applications.

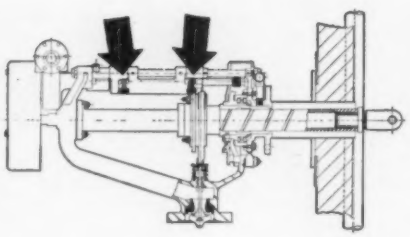
GISHOLT MACHINE COMPANY incorporates McGILL CAMROL® bearing accuracy into tooling set-ups

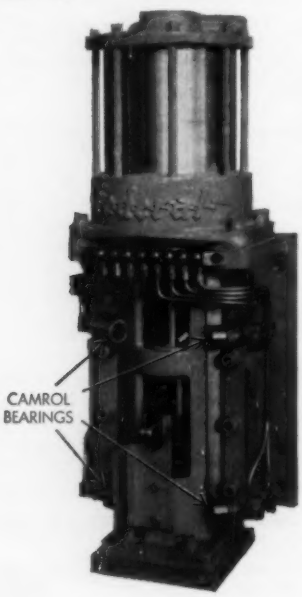


Gisholt Machine Company takes advantage of the cost and performance features of CAMROL CF series bearings, (with integral stud), on a group of standard bar tools for mounting on the turrets of Gisholt Masterline Turret Lathes. A representative tool of this group is the Multiple Cutter Turner shown.

CF CAMROL® bearings provide rolling contact in automatic soot blowers

Diamond Power Specialty Corporation has incorporated McGILL CAMROL bearings into the design of their Model IR Short Retraction blowers to produce a smooth rolling contact between cam flange and latch bar. This equipment is used for cleaning water cooled furnace walls, hopper slopes or narrow portions of tube banks adjacent to walls automatically.





FEDERAL MACHINE and WELDER COMPANY puts McGILL uniform quality into welding equipment

The anti-friction welder head unit, shown, is one of the several applications of McGILL CF CAMROL bearings in Federal Machine and Welder Co. equipment. CAMROL bearings are used in weld heads, transfer slides and various other uses where a precision, smooth, uniform movement is desired. Low cost, uniform quality, excellent performance and exceptional length of life are benefits gained in eleven years of use of CAMROL bearings.

Both the regular CF Series and the prelubricated and sealed SCF Series CAMROL bearings are used in Federal equipment.

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McGILL MANUFACTURING CO., INC., Bearing Division
201 N. Lafayette Street, Valparaiso, Indiana

PRODUCT ENGINEERING HORIZONS

June 19, 1961

When does engineering start?

The School of Business Administration, U of Minn, has just reported on a study of 106 businesses with four to 500 employes and $36,000 to $18,000,000 annual sales. It finds that 75% of businesses with fewer than 10 employes and 54% with 10 to 24 employes have no formal organization. Companies with less than $100,000 annual sales have no departments; companies with $100,000 to $300,000 have no more than two departments.

The first department to appear formally is production, says the report, followed in turn by sales, purchasing, quality control, product R & D, credit & collection, production control, market research, personnel and industrial engineering. R & D is thus fifth in line—**but where is design engineering?** If the report is accurate, this function never does appear.

This is another instance of the failure of researchers to see the obvious. How does a small company start? **Almost always with one man who has an idea for a new product.** He is his own engineer, often his own salesman as well. So the "engineering department" **is** the company, while in many cases even the manufacturing is still farmed out.

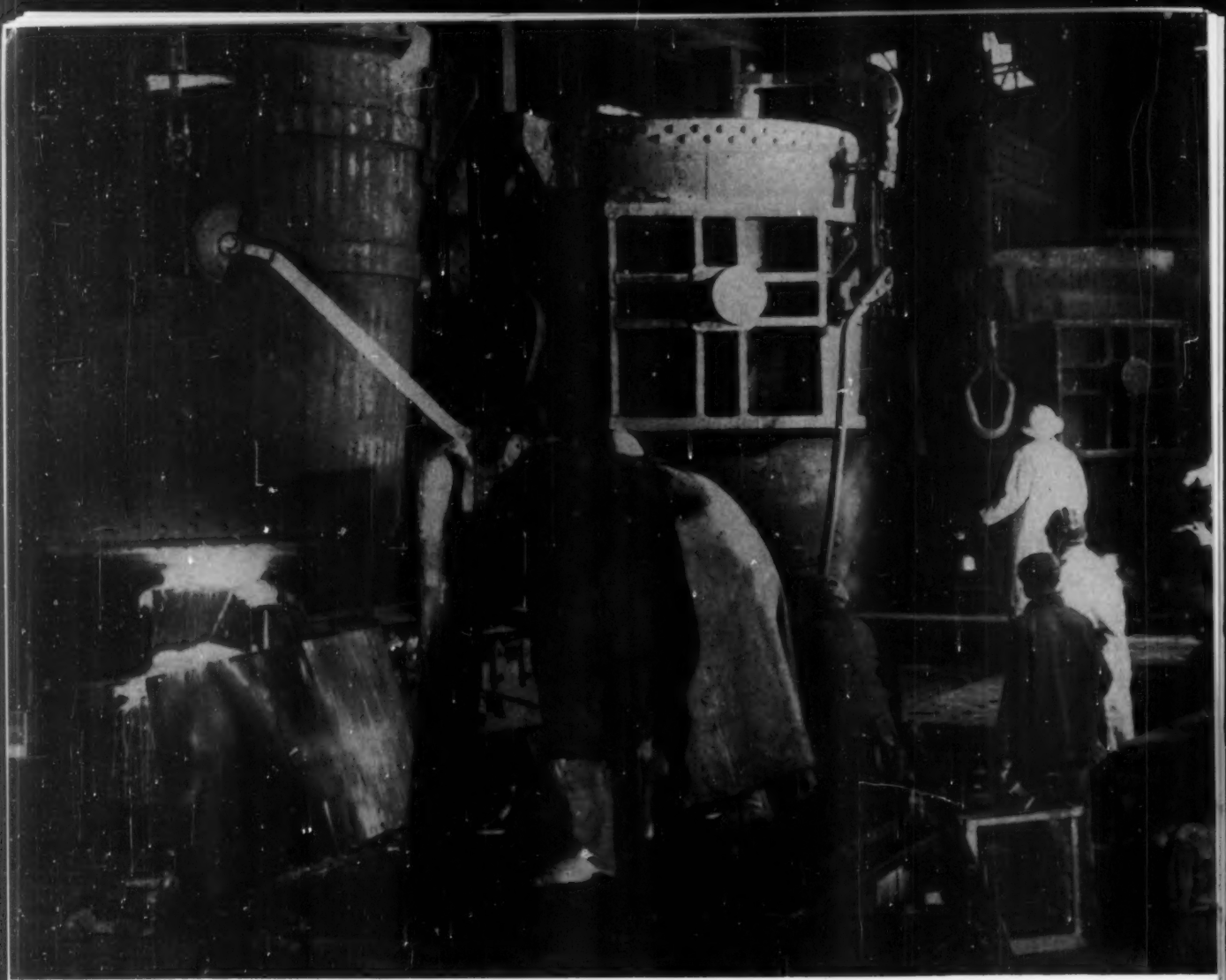
Production is a problem of duplication of the original at reasonable costs. The owner, the man with the idea, can't spend his time supervising duplication; he must get out and find out what his problems are, how his product can be improved. He can hire a man to run the plant and turn out products. So he does—and the production department is born. **But it is not the first department, only the second at best.**

Addition of sales and purchasing functions is similarly the owner's divorcement of himself from time-consuming jobs. Quality control is added as the first independent policing function.

Then comes R & D. Why? Probably because the idea man finds his technical background insufficient, because his idea has developed in strange new directions, or because he's too busy with management to handle research too. So he adds specialists, as Marconi added two physicists to make his pioneering wireless set capable of spanning the Atlantic. But he has probably previously added a draftsman or two, an engineer and a test setup. **Where are these in the study?**

Here is another example of the strange blindness that affects so many laymen, the blindness that lionizes a Gagarin and a Shepard and forgets the engineers who made their space junkets possible. **We are fed endless details of the personal lives of the passengers, but little or nothing about the engineer.**

This is, of course, as it has always been. The layman sees only the answer, not the problem that preceded it. But "B schools" should be different. If they are to turn out management men, they had best learn a basic point: **The first department in a new manufacturing company had better be engineering—or there won't be any company.**



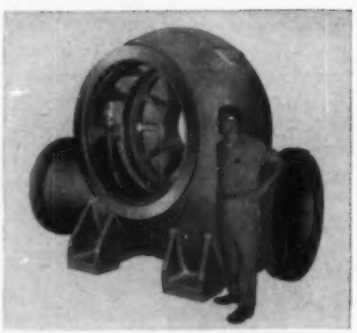
Specification steel making in Blaw-Knox Steel Foundries gives your product physical properties for maximum service

To insure the physical properties necessary for the service requirements of your product, Blaw-Knox maintains facilities for specification steelmaking including the regularly used mixes of carbon steels as well as special alloys such as molybdenum, chrome, nickel, and vanadium grades.

Ten acid open hearths, ranging in capacity from 10 to 70 tons, and two electric furnaces are available to produce exact quantities of many different grades of steel for many different castings at the same time. In some cases, as shown, huge castings weighing up to 300,000 pounds are poured simultaneously from three ladles.

Steelmaking to your order, in large or small amounts, is another part of Blaw-Knox Steel Casting Service that adds value to your product. And there's good reason why. Blaw-Knox, one of the world's leading manufacturers of rolling mills and industrial machines, knows how to keep an eye on the end-use conditions of a steel casting, make it for maximum service.

If you design or build products using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Castings Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.



This intricate pipe line booster compressor housing was cast and machined at a Blaw-Knox Foundry. Test pressure 1800 p.s.i.—working pressure—1500 p.s.i. Weight—20,000 pounds.

BLAW-KNOX

Steel Castings

CIRCLE 42 ON READER SERVICE CARD

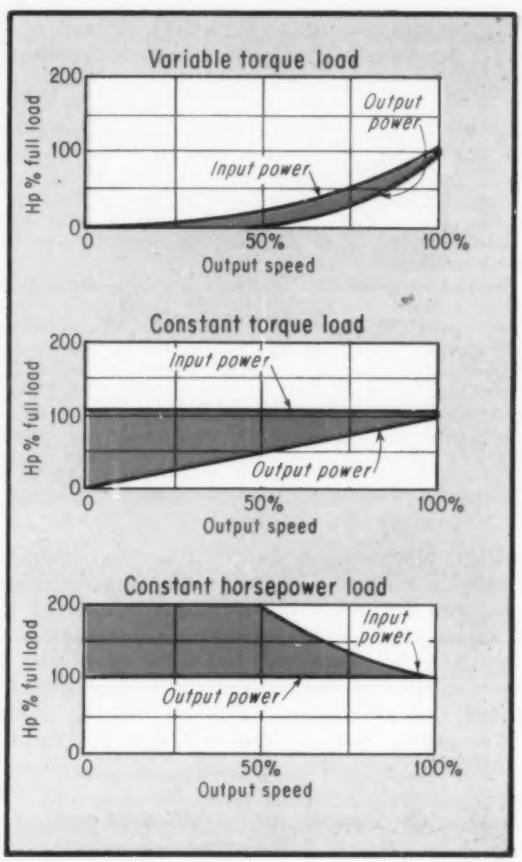
PRODUCT ENGINEERING
SPECIAL REPORT

SELECTING

CLUTCHES FOR MECHANICAL DRIVES

No longer mere switching devices, today's clutches can do a multitude of power-transmission jobs. And the choice becomes simple if you analyze the power train first—starting with the load requirement. Three-step procedure then helps you pinpoint the type, location and size of the clutch you want.

JOHN PROCTOR, *design consultant*



■ You don't have to know every detail about clutches to select one of the right type and size for any particular power train. You need only a good general idea of the range of standard types available, a fair understanding of what the different types can do—and what they can't.

The only useful measure of a clutch is its ability to handle a given job in a given system. Before you settle down to select a clutch, you must determine the actual requirements of the machine it is to go in. You can do this only by knowing your system backward and forward —backward through the prime mover, and forward through every foreseeable ramification of the load. This will take detailed analysis.

BASIC LOAD REQUIREMENTS

Start by calculating the total inertia of the load. The simple WK^2 calculations described on next page will usually be accurate enough, but critical or complicated applications may require more precise techniques. Be sure to account for the inertia of every part that is likely to receive power through the clutch, including attachments that may be added by the user of your product.

Note here that the relative WK^2 of the driven and driving members of the clutch itself must eventually be included in this figure. In many applications, high inertia is desirable on the input side—some standard clutch mechanisms are even built to be mounted inside heavy flywheels, which serve as their driving members—but the driven member must be considered a part of the total load. Its WK^2 will contribute to the power loss of the system.

Next, analyze the dynamic characteristics of the load, beginning with the starting requirements. How much torque needed to turn it over? How much more to accelerate it to running speed?

If the starting requirements are low to moderate and

REPRINTED—Circle 611, inside back cover

SOME CALCULATIONS YOU WILL NEED

Value of WK^2

Estimate the moment of inertia for the entire driven load carefully, using the formula:

$$I = WK^2$$

where I = moment of inertia, lb-ft²
W = weight, lb
K = radius of gyration, ft

To compute inertia of a hollow cylinder, find the WK^2 of a solid cylinder of the same OD, and subtract the WK^2 of a solid cylinder with an OD equal to the ID of the hollow one. To compensate for the spaces between teeth in involute gears, determine the WK^2 of a solid ring with an OD equal to gear OD, and ID equal to the gear root diameter, and multiply this value by 0.4. This value should be added to the inertia of a disk with a diameter equal to the gear root diameter.

If any part of the load is to operate at a speed other than clutch speed, compensate by means of this formula:

$$WK_e^2 = UK_a^2\left(\frac{\text{rpm}_a}{\text{rpm}_c}\right)$$

where WK_e^2 = equivalent WK^2, lb-ft², at clutch speed
WK_a^2 = actual WK^2 of load
rpm_a = speed of load
rpm_c = speed of clutch

The WK^2 value of the system helps determine the time required to accelerate the system to a desired speed, given a certain torque.

Torque

Whenever possible, measure torque requirements directly on existing equipment. In many applications, you can use the torque lever method:

$$\text{Torque} = P \times L \times SF$$

where P = pull to start load, lb
L = length of lever, ft
SF = service factor

If direct measurement is impractical, estimate clutch torque requirements with respect to the rated horsepower of the prime mover.

$$\text{Torque (lb-ft)} = \frac{\text{hp} \times 5252}{\Delta\text{rpm}}$$

Δrpm = (initial rpm − final rpm)

If the driven load has flywheels or other heavy parts that must be accelerated to full speed in a limited time, the average torque required for this acceleration must also be included in your calculations. This torque is required in addition to that needed to overcome friction and other normal load forces.

$$\text{Torque} = \frac{WK^2 \times \Delta\text{rpm}}{308t}$$

where Δrpm = (initial rpm − final rpm)
WK^2 = total inertia of load, lb-ft²
t = required starting time, sec

Period of Acceleration

The time required to accelerate a given load, on the other hand, can be estimated as follows:

$$t = \frac{WK^2_p \times \text{rpm}_{clutch}}{308 \times \text{rated clutch torque}}$$

where WK^2_p = effective inertia of load at prime mover

Heat Dissipation

A clutch will overheat and may burn out if it cannot dissipate the heat it generates in slip. Where slip is constant, calculations is simple:

$$E = \text{hp} \times \%\ \text{slip}$$

where E = energy or heat input, hp
hp = actual power input to clutch

$$\%\ \text{slip} = \frac{\text{clutch output rpm}}{\text{clutch input rpm}}$$

Where slip is frequent or cyclic, it may be easier to calculate E_T, heat input in ft-lb per unit time (per minute in some automated clutches; per hour in most utility clutches). This value is translatable into horsepower or any other convenient unit.

$$E_T = 0.00017 \times WK^2 \times N \times f$$

where WK^2 = total inertia of all driven parts
N = initial rpm² − final rpm²
f = number applications/unit time

Note that energy to be dissipated increases by the square of the speed, whereas the torque on engagement is only inversely proportional to the speed differential between the clutch members.

Calculation of moment of inertia has been discussed in several earlier articles recently brought together in a combined reprint "WK^2 and Motor Selection." Articles include "Significance of WK^2 and How to Calculate It," with radius of gyrations for common geometrical forms, "Drive Accelerations Time," offering a simple test procedure; and "WK^2 for Flywheel Effect," with graphical data on inertia in standard V-belt pulleys. Copies of this 64-page booklet may be obtained for $2 (remittance with order) from Reader Service Dept, Product Engineering, 330 W 42nd St, New York 36. ■

not too much greater than running-torque requirements, you will need a clutch that offers the characteristics shown in top chart on preceding page. With this load (centrifugal fans, pumps, and blowers are typical examples) torque varies with the square of the speed, and horsepower varies as the cube. The basic slip pattern indicated will tell you something about type of clutch needed.

If there are high-inertia bodies in the load, or if there is a high breakaway-torque requirement, the clutch may need the characteristics shown in middle chart.

Here, torque must be delivered at an essentially constant level, while hp output varies directly with load speed.

Loads of this basic type must be further differentiated as "smooth" or "fluctuating." The smooth type is characteristic of equipment with high-inertia parts that develop sufficient momentum to damp out torsional fluctuations. (Examples: machine tools, reciprocal pumps, compressors fitted with flywheels.) The fluctuating type, which tends to wobble around an average torque requirement, is characteristic of breakaway loads (examples: rotary kilns, conveyors, mixers, bell and hammer mills). Such a load may require a clutch that can damp out torsional vibrations and resonance, besides performing its more basic functions.

In some specialized applications, load problems can become extremely complicated. Winding and coiling machines, for example, frequently require constant tension to be maintained on a web of delicate material as it is reeled onto a cylinder; this cylinder is progressively picking up inertia and losing speed as more and more of the material is reeled in. Horsepower require-

ments of such a load remain essentially constant—and independent of speed—because torque varies inversely with load rpm. Obviously, a special clutch is required in such an operation. (For the characteristic speed-power curve of such clutches, see the bottom chart on page 43).

Notice the hidden dynamic factors in some of these examples: Mixers change their power requirements in the course of operation, because mixing changes the consistency of the materials they handle; the effective WK^2 of a winding reel changes constantly in operation, because the mass of the material wound on it at any time determines both its weight and its radius of gyration. Don't overlook any dynamically variable "sleepers" in your application. And don't forget to make due allowance for the effects of time and wear.

And as you analyze the load, don't lose sight of the final purpose of the clutch. For example, take another look at that top chart, p 43. If your application calls merely for the acceleration of such a low-shock, low-friction load to a constant running speed, you can probably do with a standard friction clutch of sufficient capacity to dissipate the heat generated in the modest slippage required of it. But suppose you have to operate that pump or fan at variable speed. With an entirely different kind of clutch—one designed for constant-slip operation—you can drive its operation by regulating the clutch. In such jobs, the clutch can be considered a variable-torque drive.

Similarly, some clutches with the factors shown in middle chart are built to accelerate heavy loads to constant running speed; others are designed to regulate a constant-torque load by continuous slip.

Checklist below will help analyze your load requirements.

Figuring these things out will take time. It will be a lot of trouble. But weigh this against the time and trouble involved in working the bugs out of a system with a clutch of the wrong type, or of inadequate capacity. Every requirement you anticipate will simplify the final selection.

Next step should be an appraisal of the prime mover.

THE PRIME MOVER

In most applications, it's load that determines the type of clutch required, but it's the type of prime mover driving the system that strongly influences choice of clutch. Sometimes, this decision quickly eliminates several types of clutches from consideration. On the other hand, type of clutch employed can decide type and capacity of driver.

The acceleration of a high-inertia load, for example, can frequently be handled either by a high-starting-torque or high-slip motor, driving through a conventional friction clutch, or by a standard NEMA B motor, driving through a centrifugal clutch or fluid coupling. If specification of the motor is still flexible, you may profitably compare the relative advantages of these alternative systems. (But don't try to combine the special clutch and the special motor; they will fight one another.)

Automatic clutches can also smooth and limit starting current and eliminate the need for auxiliary low-voltage starting equipment.

Where starting torques are normal and standard utility clutches are employed, limiting characteristics of the prime mover can be compensated for by derating the capacity of the clutch. If the drive is inherently smooth—as with electric motors and steam or water turbines—little if any compensation is required. If the same load is driven by an internal combustion engine, clutch capacity may have to be increased to absorb the impulse torques. This factor may not be critical where the impulse is moderate, as with engines of four or more cylinders, operated at speeds above 700 rpm. For rough-impulse drives (engines of 1 to 3 cyl, or speeds below 700 rpm), clutches must be considerably larger than normal.

In selecting any clutch, the following characteristics of the prime mover must usually be considered:

- Type
- Ratings: Electric motors: hp, sync speed, phase cycle
  Engines: hp, min operating rpm, no. of cylinders
- Actual running speed: max and min
- Actual hp at minimum rpm
- Idle or warm-up speed (max)
- Overload capacity
- Shaft and keyway

THE POWER TRAIN

When you have made separate examinations of the prime mover and the load, stand back for a look at the entire power train:

1. Determine the relative speed between drive source and load, both starting and running. Note whether direction of rotation is clockwise, counterclockwise, or reversible. Some clutches work in only one direction.
2. Decide, tentatively, on location of clutch and consider these drive possibilities to and from the clutch:

- **Direct in-line coupling**
- **Gears, or chains and sprockets** (determine speed ratios)
- **Belts**

continued, next page

CHECKLIST FOR LOAD ANALYSIS

- **Purpose of machine**
- **Desired function of clutch**
- **WK of all driven parts, with particular attention to dynamic variables (breakaway, flywheel effect, etc)**
- **Load running speed (constant? variable? same as driving source?)**
- **Starting-torque requirements**
- **Running-torque requirements**
- **Period of load acceleration**
- **Duty cycle (if continuous, hr/day; if intermittent, hr/day and starts/hr; if cyclic, frequency)**
- **Normal operation:**
  Non-pulsating or pulsating?
  Smooth (low starting torque; running load steady)
  Light shock (starting torque somewhat greater than running torque; peak loads fairly low and infrequent)
  Heavy shock (starting torque and peak loads 200% to 250% of running load; frequent heavy shock or load reversal)
- **Overload: Likely to jam? To overrun the driver?**

3. Consider the various alternative modes of control and provide—again, tentatively—for any necessary control loops and auxiliary equipment. Here are the alternatives:

- **Manual operation** (or pedal)
- **External control** (mechanical, electrical, pneumatic or hydraulic control of clutch operation)
- **Automatic** (the clutch is self-actuating)

4. Note any special requirements for quick accessibility —not merely to the clutch itself, but to the parts to which the clutch will be connected.

GENERAL REQUIREMENTS

You are now almost ready to think about selecting that clutch. But first, try to anticipate any special problems a clutch may raise as a key component in your final product. For example, if the machine is to run unattended, it may be necessary to provide special protection against overheating.

Finally, there are the usual inescapable factors that should always be settled in advance:

- **Environmental requirements**
- **Space and weight limitations**
- **Life**
- **Price range**

When you know precisely what you require of a clutch, process of selecting and specifying becomes relatively simple.

THESE ARE THE SELECTION STEPS

Two distinct problems await your decision. First, you must pick the type of clutch best adapted to the kind of job that must be done. Second, you must specify a size big enough to handle the actual load efficiently under all the critical service conditions that can be foreseen.

A general procedure for attacking these problems can be reduced to three logical steps:

1. Define precisely the functions required of the clutch, and find the type of clutch that can most effectively perform them. The tables and text in the last half of this article are designed to help you in this initial screening.

2. Next, complete your system layout. The position of the clutch in the drive will determine operating speed and other basic considerations that limit choice of clutch size.

3. Contact one or more suppliers who sell the type of clutch you propose to use, and follow the method set forth in each individual catalog to order the size of clutch your application requires. In most cases, this will mean multiplying service factors into a list of standard values. For reasons we will see soon, there are relatively few general rules that can be applied at this stage of the game. Briefly, the problem is that each company catalog is built on a closed system, which must be dealt with on its own terms if nominal ratings are to mean what they seem to mean. (Chances are the supplier's sales or service department will want to work closely with you all the way. You may find this cooperation very helpful—but don't abandon your sales resistance completely.)

These are the general steps. Each requires more specific detail. The first—selection of clutch type—will be covered in the last half of this article. The other two, which are equally important, can be dealt with immediately.

Where to put the clutch

In some cases, position of the clutch will have to be determined by space limitations, rather than by transmission principles. Sometimes it will depend on the type of driver, or the type of load. Usually, there will be a choice—not necessarily an easy one.

Is it better to install a large clutch on a slow-speed, high-torque shaft, or a smaller, cheaper clutch on a high-speed, low-torque shaft? There is room for heated opinion on both sides of this question. One major supplier holds for the economy and "possibly greater efficiency" of always picking the high-speed shaft whenever there is a reasonable choice. Other companies take the opposing view—that the higher initial cost of the low-speed unit is counterbalanced in the long run by "less maintenance, downtime, and expenditure on spare parts."

It is a problem to which there is no easy answer. If a large clutch is applied at the low-speed side of a reduction unit, engine torque must be multiplied by the gear ratio to determine the actual torque the clutch will have to handle. Shock and torsional fluctuation may be multiplied correspondingly.

On the other hand, the energy to be dissipated by a clutch increases as the square of the speed, whereas the torque on engagement varies inversely with the speed differential between the stationary and rotating members. In other words, a clutch that is both too fast and too small will overheat instead of picking up the load. As to economy, high-speed clutches may require antifriction bearings instead of simple bushings. If the speed is high enough, dynamic balancing may be necessary.

The best expert opinion seems to be that the higher speed is generally preferable, but that each system must be evaluated carefully on its own terms.

Wherever you decide to put the clutch, mount it as close as possible to existing shaft bearings. It may otherwise need special support. And don't attempt to support a clutch on its own pilot or throwout bearing.

Determining clutch size

The size of a clutch is critical. A clutch that is even slightly too small for the job it has to handle is a troublemaker. It won't pick up the load, and it won't be able to dissipate the heat produced by the constant power loss. If it does not burn out completely, slipping surfaces may be so warped that effectiveness or even control will be lost. If it is a friction clutch, the coefficient of friction may change drastically with rising temperature.

A clutch that is much too large, on the other hand, can exceed the overload capacity of the motor that drives it. It can keep engine speeds below peak torque levels, and thus prevent the desired load acceleration.

It is generally advisable to check the final determination of capacity with the supplier. Most clutch manufacturers maintain a staff of applications engineers. But to take full advantage of their free services, you will be required to draw up a fairly detailed specification covering the load and power source and describing your application fully with a legible sketch. Most companies have prepared standard forms to assist you.

If you order by catalog, instead of preparing a specification, be careful. Follow the directions—even when they

seem unnecessarily complicated. If your application falls between two ratings on any consideration (overload capacity, shaft size, etc), always pick the larger. And use the service factors: they are important.

Service factors

Most major suppliers have developed more or less elegant procedures for calculating the capacity required of their clutches. A fairly standard practice is to catalog models by nominal horsepower at 100 rpm, and to multiply this figure by one or more service factors before shifting the decimal and dividing by actual clutch rpm. An alternative method is to multiply service factors into torque computations.

According to a number of the manufacturers who contributed data for this report, one of the commonest causes of clutch trouble is the customer's failure to apply adequate service factors in his original calculations. It is elementary: if the SF (service factor) is too small, the clutch will be too small.

Up to a point, the customer's disinclination to take service factors seriously is understandable—however mistaken it may be. The service factors recommended by different companies for the same circumstances can vary considerably—so much that they may seem, at first glance, to be completely arbitrary. When one company recommends a factor of 1.5 where another calls for a factor of 3, is the second company simply over-conservative? If the lower figure seems logical, won't it serve as well?

The answer to both questions is "Probably no." It is a mistake to tamper with either company's figure.

In the first place, different manufacturers follow different standards in setting nominal ratings. In other words, the figure to be multiplied by the SF may be based on an actual average value (for example, on the actual torque at which a properly adjusted and aligned clutch will slip), or it may include a built-in safety factor. Some companies weight their nominal ratings by as much as 100%. In this case, the apparently irreconcilable service factors would actually be identical.

It is generally safe to assume, furthermore, that a company's ratings and service factors have been proved out empirically, and that they have been found to work. Differences in service factors may reflect real differences in performance and design. It is not just a question of piling up a "margin of safety."

Far from it, in some cases. Horsepower in clutches, like wattages in electronic components, must be realistically derated with rising temperatures. The service factors, in effect, provide a new set of nominal ratings for clutches intended to operate under abnormal conditions ("abnormal," that is, with respect to the norm by which the basic ratings are made).

For overload protection

Within all these limitations, these general rules apply:

- In selecting a clutch that offers overload protection to an internal combustion engine, determine the lowest speed at which the engine will idle satisfactorily, and specify a clutch with a release speed set high enough above this point to allow for the drag torque developed over extended idling periods.
- If the system is driven by an electric motor, specify a clutch with a torque capacity slightly lower than motor breakdown torque at a speed slightly above the point at which an abrupt drop could occur; thus, an overload will cause the clutch to slip while the motor runs continuously at reduced speed.
- For straight overload protection, the load value should fall within the range of 25% to 75% of the clutch rating. Operation may be rough if the clutch is set to slip under extremely light tension.
- Never use a clutch to transmit less than 10% of its nominal rating.

CLUTCH TYPES

The kind of clutch you can use will be determined by its function. But that, in turn, requires a preliminary understanding of the basic clutch types available. In the long run, you are probably more concerned with what a clutch can do than with how it manages to do it; nevertheless, certain principles of clutch design must be considered whenever clutches that can perform the same function are compared. Moreover, clutches are best specified in terms of basic construction and control capability.

A clutch is a mechanical switching device that will control the flow of torque through a power transmission system. Its driving member and driven member must somehow be brought into contact, or otherwise coupled to one another, and each must be connected to the power train. In terms of elemental clutch design, therefore, three parameters must be considered:

1. The physical principle employed to transmit torque from one member to the other.
2. The means by which the members are engaged and disengaged, or by which their relative speed can be controlled.
3. The means by which the driving member is connected to the drive source, and by which the driven member is connected to the load.

THESE COUPLING METHODS

Five major types of clutches can be distinguished, based on the means adapted to couple the two clutch halves, without regard for the mode of controlling this operation:

1. Positive-contact clutches

In this general type, the engaging surfaces interlock to form a rigid mechanical junction. There are three basic designs (illustrated on next page):

- **Square-jaw clutches,** ranging from the simple rough-cast "claw" to a variety of highly machined, multi-jawed devices for specialized heavy-duty applications.
- **Spiral-jaw clutches,** which have intermeshing ratchet teeth that permit operation in a single direction.
- **Tooth clutches,** which employ triangular and rhomboidal gear-tooth designs, variously modified for strength or speed.

2. Friction clutches

Probably the simplest clutch that works by friction is the variable-pitch V-belt pulley which can be opened out to release the belt or closed fully to grasp it. Intermediate positions permit the belt to slip.

The conventional friction clutch is the most common of all clutch types, and the most diversified. Essentially

it has two or more opposing surfaces that can be forced firmly into contact with one another. As a rule, at least one surface is lined with a material having a high coefficient of friction. When engaged, the clutch members tend to rotate as a single unit, but they are free to slip as long as they are not in equilibrium. The ability to slip brings both advantages and limitations: slippage cushions shocks and protects the entire system from overloads; on the other hand, it creates problems of heat dissipation that can seriously prejudice performance.

Some friction clutches are built to slip continuously; most are designed primarily for "on-off" operation, where slip is only intermittent and exceptional.

It is traditional to classify friction clutches according to the plane in which they operate:

Axial types (disk and plate clutches), the most common variety, operate in a plane perpendicular to the shaft. The simplest form is little more than a pair of flanges, mounted at the ends of two in-line shafts, with some means provided for sliding facing surfaces into forceable contact.

Standard models are a little more complex: they have one or more friction disks, which can be clamped between fixed and moving plates in the clutch mechanism. The internal pressures exerted by this vise-like gripping arrangement run extremely high—for example, the force between the two disks in a typical utility clutch rated for 40 hp at 100 rpm is something over 10,000 lb.

Torque capacity of such clutches can be multiplied readily by increasing the number of disks. Theoretically, capacity is doubled by adding one extra friction plate, tripled by adding two, and so on. There are practical limitations to this practice, however. Multiple-disk clutches tend to overheat, and complete release is difficult to obtain. They offer the clearest advantage in static or low-speed applications where high static torque is required. In clutches for high-speed dynamic use, the fewer the friction surfaces, the better.

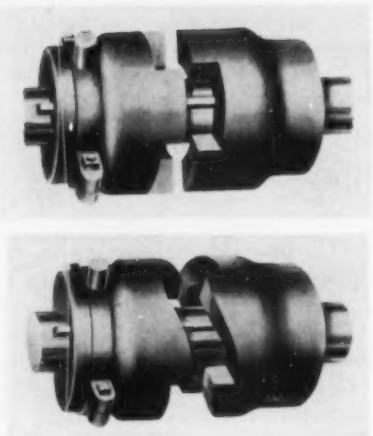
Radial types (ring, shoe, band, or rim clutches) operate on a common axis with the shaft. The friction surface is cylindrical, and the opposing mechanism moves into contact radially, either by expanding outward toward the rim, or by contracting inward, toward the hub. (Some versions have a combination of expanding and contracting parts.) Clutches of this type are frequently built directly into pulleys and flywheels.

Cone clutches offer a composite operation: the clutching surfaces—slightly tapered—are coaxial with the shaft, so that the thrust load is primarily radial, but they are engaged by pushing the parts together axially. The action is similar to that of thrusting a cork into a tapered bottleneck; it allows a heavy-power-transmitting torque with a relatively light engaging force, but it also has a tendency to grab and a reluctance to disengage. Formerly popular (cone clutches were used extensively in early cars) the type has gone out of fashion in this country, and development has lagged as the industry has concentrated on other types. Cone clutches are still common in Europe, with modern English and German designs available here.

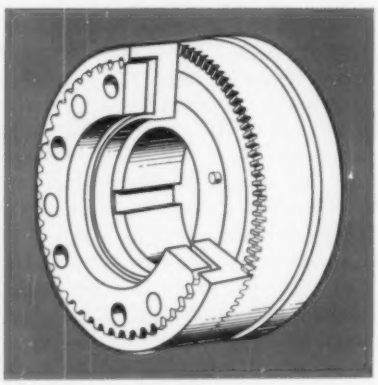
3. Overrunning or freewheeling clutches

Either of two basic principles govern clutches of this type; wedging or wrapping. In either case, the driving and driven members are coupled—under certain conditions—by the elastic tension of an intermediate member. There are three basic variations:

- **Roller**—the members are wedged together by the action of concentric balls or rollers riding on a camming race.
- **Sprag**—eccentric cams pinched between concentric races.
- **Spring-wound**—the members are bound together by a helical spring that produces a powerful, torque-multiplying gripping force comparable to that of a hawser snubbed around a capstan.



Square jaw clutch (top), spiral jaw clutch (bottom), Link-Belt Co



Tooth clutch, Bendix Corp

4. Magnetic clutches

In terms of basic design, this class includes only the types that employ magnetic forces to couple the clutch members. To avoid confusion with electrically actuated friction clutches (magnets employed mainly for control) these clutches are sometimes referred to as "magnetic flux couplings" or "magnetic drives." Three common types are available for power transmission:

Magnetic particle (or magnetic fluid) clutches exploit the ability of a ferromagnetic powder, in presence of a magnetic field, to transmit torque from one clutch member to the other. The annular working gap between the driving and driven members is partly filled with a mixture of iron

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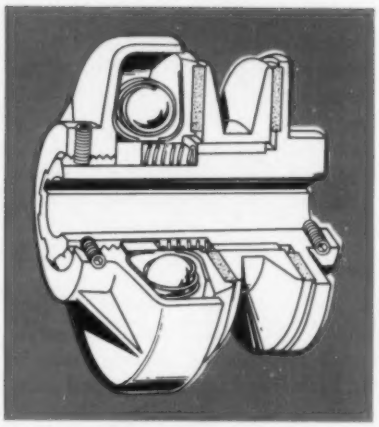
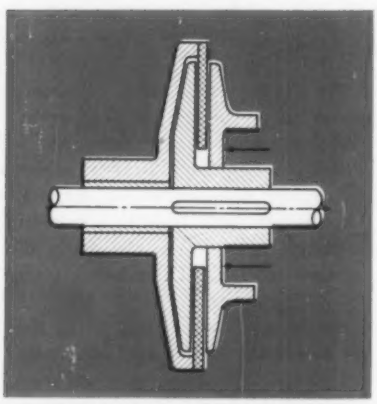
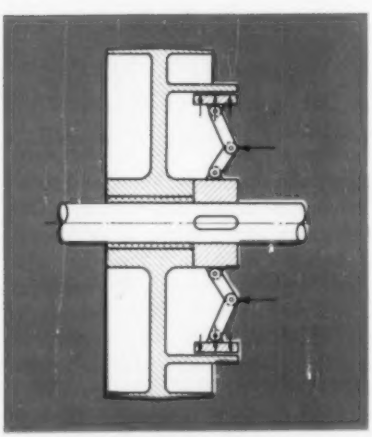


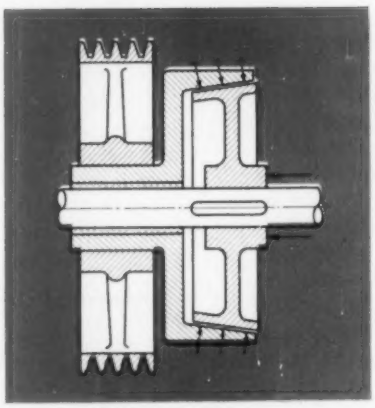
Variable-pitch V-belt pulley. Cutaway shows automatic centrifugal operation, Salsbury Corp



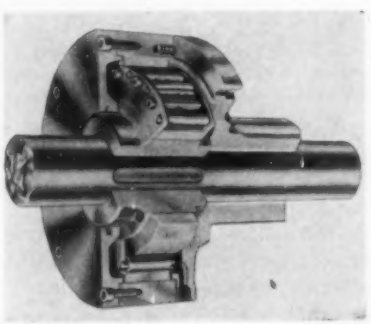
Axial (disk) friction clutch. The mechanism which produces pressure between the plates is not shown, since many different types are used in various clutches, Dodge Mfg Corp



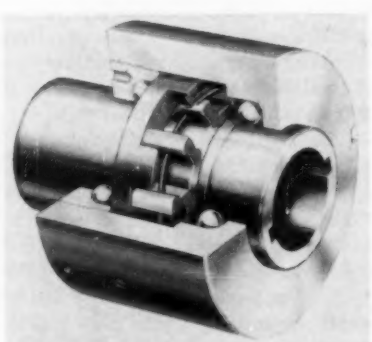
Radial-type friction clutch. Others use external contracting or internal expanding brake bands, Dodge Mfg Corp



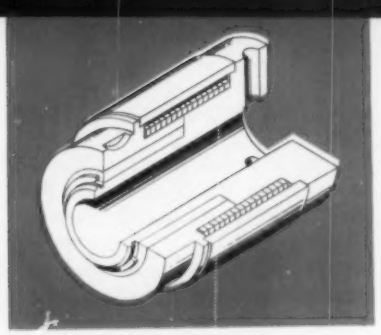
Cone clutch. Mechanism which slides the cone into the ring is not shown because many different methods can produce necessary pressure, Dodge Mfg Corp



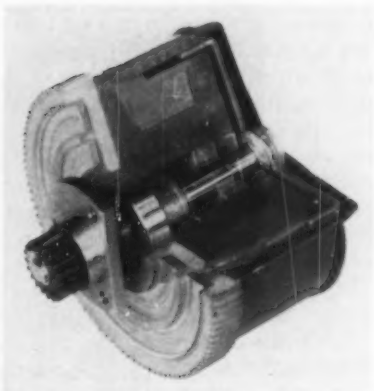
Overrunning clutch, roller type, Hilliard Corp



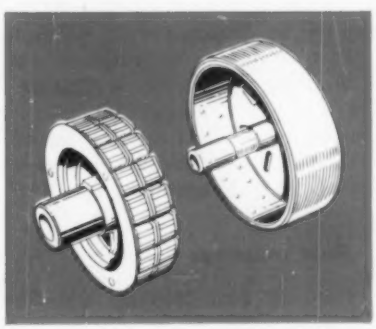
Overrunning clutch, cam or sprag type, Formsprag Corp

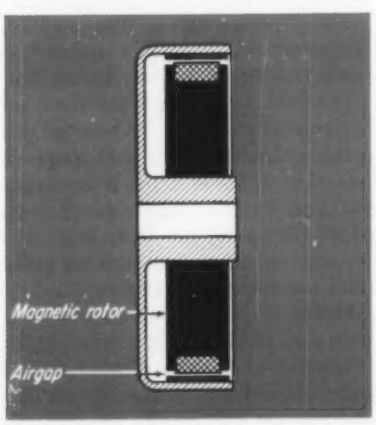


Spring-wrapped overrunning clutch, Curtiss-Wright Corp



Magnetic particle clutch, Lear Inc





Eddy current, permanent-magnet type, Tormag Products Div, Gleason Reel Corp

particles and lubricant. ("Magnetic particle" clutches employ a dry lubricant, such as flake graphite; "magnetic fluid" clutches suspend the powder in an oil.) When a magnetic circuit is induced through the gap by a dc control coil, the iron particles form into "chains" which shear less easily, depending on the strength of the field, and the clutch is permitted to slip.

Hysteresis clutches are entirely magnetic (no mechanical contact between the members, except for bearings and —if a rotating coil is used—for brushes and collector rings). In a typical unit the high-hysteresis hard-steel rotor surrounds a slightly smaller magnetic rotor into which a number of isolated Alnico permanent magnets have been cast, or in which a rotating magnet coil is housed. Salient poles on the magnetic driven member induce corresponding magnetic poles within the constant-speed steel driving member, across an airgap; once established, these poles resist displacement and tend to maintain their alignment rather than assume a new relationship. The two members thus rotate synchronously, as if directly coupled, as long as the load does not exceed the torque rating. They can also slip continuously to maintain a constant torque output that is substantially independent of speed.

Eddy-current clutches, are similar in construction to hysteresis clutches, except that a soft-iron or special mild-steel rotor is substituted for the high-hysteresis member, and the magnetic segments are interconnected to induce eddy currents and inhibit hysteresis. Both types can be illustrated with a single typical cross-section. Characteristic operation, however, is fundamentally different. Slip is required to develop torque, which results from the dissipation of eddy currents through the electrical resistance of the rotor ring. In electromagnetic units, output torque can be regulated over a wide range by varying the excitation current. These clutches are inherently speed-sensitive, and require a coupled tachometer generator to maintain precise speed control.

5. Fluid couplings

The only fluid couplings considered here are simple, automatic fluid drives. Hydraulic variable-speed transmissions are beyond the scope of this article.

Two types of simple fluid coupling are designed to be substituted for, or used in conjunction with, the standard mechanical and electrical clutches that concern us:

Dry-fluid couplings contain a measured amount of heat-treated steel shot. When the prime mover is started, centrifugal force throws this charge to the perimeter housing, which is keyed to the input shaft, and packs it against the rotor, which transmits power to the load. At predetermined full speed, the shot charge is packed solid and the housing and rotor lock together without slip, unless overloads exceed a set torque limit.

Hydraulic couplings, or traction fluid drives, consist simply of an impeller, or centrifugal pump, and a runner rotor or turbine wheel, which face each other in a housing partially filled with oil. Torque is developed by slip, since the pressure differential between the impeller and the runner rotor, which causes the fluid to circulate and transfer energy, is a function of the difference in speed between the members. Normally, 2% to 6% slip is needed to develop full torque.

MODE OF CONTROL

Clutches are also categorized by the means used to actuate them. Two factors may be involved here: control of engagement, and control of slip.

The first is important where primary function of the clutch is to operate as a simple on-off switch, capable of transmitting full power in one position and no power at all in the other.

Control of slip will concern you mainly when the clutch is to serve either as a variable operating control, or as an automatic safety device.

Control of engagement

There are three basic modes of control: manual, external, and automatic. Reduced to general principles, the mechanisms by which these modes can be obtained may be described as mechanical, electrical, pneumatic and automatic. Hydraulic control mechanisms are being developed as well, and clutches with true hydraulic shifts have begun to appear on the market. Usually however, hydraulic pistons are still used merely to actuate mechanical linkages, which—in turn—actuate the clutch; therefore, hydraulic control mechanisms are not specifically covered here.

Mechanical controls

There is no end to the levers and linkages, over-center toggles, balls or rollers working over cams, rocking wedges and sliding wedges, and other contrivances developed to obtain mechanical advantages at maximum efficiency. Most mechanical shifts can be operated either manually (by direct levers for small clutches; through compound linkages or handwheel-driven gearing for the really big ones) or by remote control—mechanical, electrical, pneumatic or hydraulic.

Even when the external control is fully automatic, it is confusing to refer to the controlled unit as an "automatic" clutch. An automatic clutch is self-actuating—even when responsive to manual throttle control; a mechanical clutch must be actuated through linkages which may be shifted by solenoid, electric motor, air cylinder or hydraulic ram.

Mechanical controls generally require special lubrication and maintenance. Frequently, the control mechanism takes up much more room than the clutch it operates.

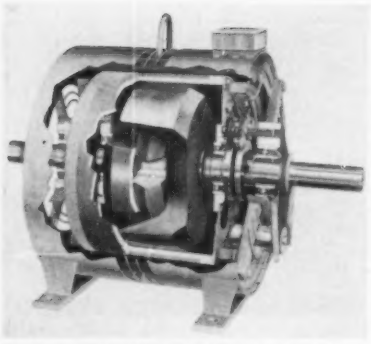
Electrical control

Some clutches offer true electrical control—where the magnet serves not to actuate a shift mechanism, but to eliminate it.

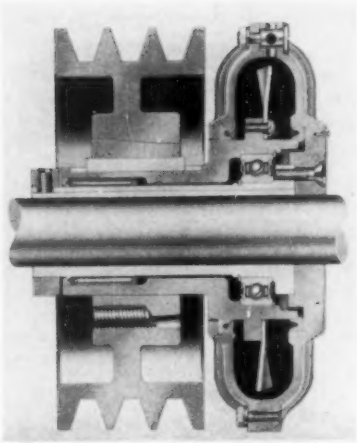
Standard electromagnetically operated friction and tooth clutches are electrically engaged and spring-released. This makes them fail-safe, because they release automatically when there is power failure. Most suppliers also offer spring-engaged, electrically released models for economy in applications where the duty cycle requires that shafts be coupled for longer periods than they are uncoupled.

The electrically controlled clutches are available in two basic magnetic designs:

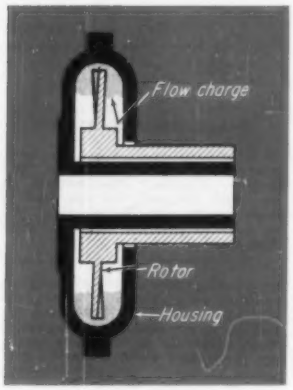
Rotating-field have rotating coils, energized through slip rings and brushes subject to wear, sometimes chatter, and may produce sparking which would be hazardous in explosive atmospheres. The rotating coil generally increases inertia and may cause dynamic unbalance.



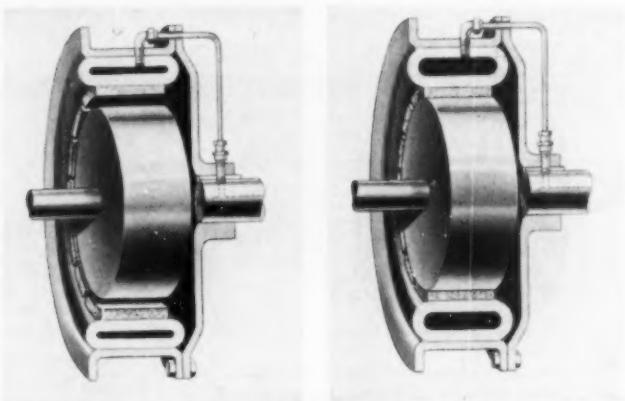
Eddy current, electro-magnetic coil, Electric Machinery Mfg Corp



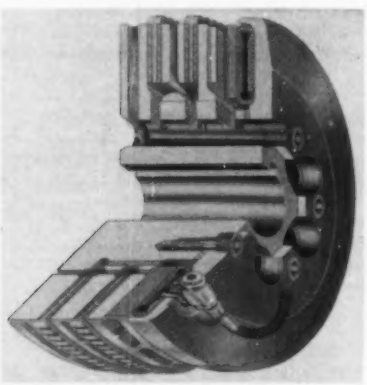
Dry fluid coupling, Dodge Mfg Corp



Hydraulic fluid coupling, Liquid Drive Corp



Pneumatically operated radial friction clutch, Fawick Airflex Co



Pneumatically operated axial friction clutch, Wichita Falls Foundry & Machine Co

Fixed-field have stationary coils, which eliminate most of the disadvantages of the rotating-field design, but create certain disadvantages as well. Such clutches require three members, where the other has two. They demand sturdier bearing support and closer alignment tolerances; are generally more expensive, both initially and in operation, since they must maintain a magnetic circuit through extra airgaps. Several suppliers offer electrically actuated friction clutches designed for frequent or continuous slip and susceptible to variable control. They also build standard control packages.

Magnetic-particle clutches and hysteresis and eddy-current clutches that do not employ permanent magnets also require electrical control, of course. All electricity-controlled magnets considered here require dc power.

Pneumatic control

Many air-operated clutches simply incorporate pneumatic pistons or pressure plates as key parts in a system of mechanical linkages. Some, however, are controlled by direct air actuation. Typical of the latter are friction clutches that use an inflatable tube, or gland, to apply the pressure required for the engagement force. Both radial and axial types are available. With adequate auxiliary control packages, they permit close regulation of the degree of "grip" between the members; are without linkages; are automatically self-adjusting; and offer a limited flexible-coupling capability to cushion shock, compensate for minor misalignment, and damp out torsional vibration. These clutches, too, are inherently fail-safe—automatically release on any interruption of the compressed air supply.

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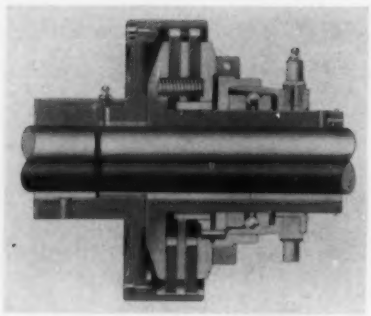

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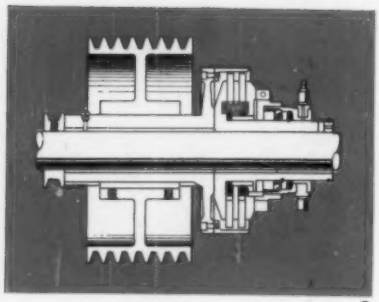

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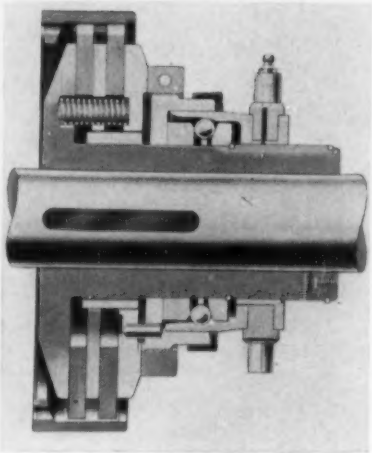

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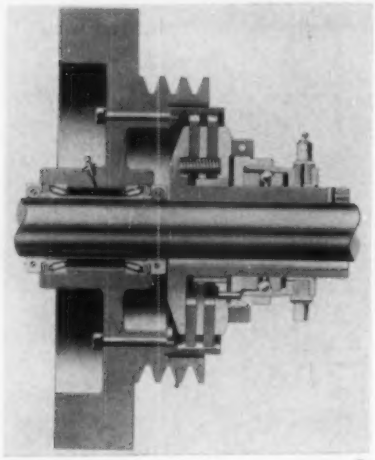

D

DRIVE ARRANGEMENTS

A Direct connection between two in-line shafts. Mechanism is mounted (keyed) on one end of shaft, with cut-off coupling hub on end of mating shaft, Dodge Mfg Corp

B A typical utility clutch mechanism consists of clutch hub with pressure plate, friction disks and operating parts mounted on outside. Mechanism is a complete working part, but must be built into pulley, sleeve, cut-off coupling hub or flywheel before it can be used to transmit power, Dodge Mfg Corp

C Mechanism, complete with loose sleeve, carries sheave, pulley, sprocket or gear. Entire clutch assembly is mounted on shaft which it couples indirectly with parallel shaft through belt, chain or gear drives, Dodge Mfg Corp

D Flywheel clutch. Operates on same principle as the sleeve type. Mechanism here is built directly into the pulley or flywheel, and sleeve is eliminated, Dodge Mfg Corp

Automatic control

Automatic clutches are completely self-actuating. Instead of responding directly to external control, they react reflexively to predetermined conditions as they arise.

Automatic friction clutches and dry-fluid couplings work on centrifugal force. The terms "centrifugal clutch" and "automatic clutch" are used interchangeably.

Overrunning or free-wheeling clutches also operate automatically, except in special single-revolution and indexing modifications–and even there, the operation is automatic after the externally applied trigger has removed the restraints. In the overrunning clutches, automatic engagement and disengagement is determined by inherent limitations built into the cams or springs employed.

With eddy-current clutches using permanent magnets, and with hydraulic fluid couplings, automatic torque regulation is a function of slip.

Control of slip

Clutch slip can also be either externally or internally controlled. Where there is mechanical control of engagement, slip can be controlled externally by gear-driven micrometer screws that regulate the degree of "grip" between friction surfaces.

With electromagnetic control, slip can be regulated by the current supply; with direct pneumatic control, slip may be regulated by metering the air supply.

Internally controlled clutches are set to slip automatically under predetermined load conditions. In disk clutches, it is usually a question of spring-loading. In centrifugal clutches, several approaches are possible–as we shall see. The slip of fluid couplings is determined primarily by the amount of fluid charge.

DRIVE ARRANGEMENT

Clutches must also be specified in terms of simple physical configuration, without regard for principles of operation or modes of control. Two basic designs are available:

Cutoff couplings provide a direct coupling of two in-line shafts.

Sleeve clutches permit the indirect coupling of two parallel shafts, frequently through a reduction. Driving and driven members are mounted axially. One-half can be mounted on a pulley, sheave, or gear; the other half is keyed to its shaft.

FINDING THE KIND OF CLUTCH YOU NEED

The clutches we have described can be adapted for various kinds of operation. In terms of function, there are four general categories:

• **General utility.** As the name suggests, these are designed to be generally useful. These clutches are comparable to on-off switches in electrical circuits: they permit power to be applied and removed at will, by the closing or opening of a connection between the power source and the load. All clutches in this category require some form of external control.

• **Self-actuating.** They work automatically. All these clutches and couplings allow a load to be accelerated at

I—SELECTION CHART FOR 4 MAJOR CLASSES OF CLUTCHES

Function	General Utility	Centrifugal and Fluid Self-Actuating	Continuous Slip		Overrunning or Freewheeling
			Automatic	Variable	
No-load Start: Manual or externally controlled	√				√
Automatic		√			√
Smooth Load Pickup: Normal load	√	√	√		
High-inertia load		√		√	
High-breakaway load (more than 100% running torque)		√		√	
Automatic delayed pickup		√		√	
Extended acceleration		√		√	
Auxiliary starter					√
Running Operation Normal load (no slip at full load, full speed)	√	√	√		
Control variable-torque load				√	
Control constant-torque load			√	√	
Control constant-tension load				√	
Overload Protection and Stopping General protection: transient and infrequent overloads	√	√			
Limit speed (prevent runaway load)		√			√
Limit torque		√	√		√
Automatic overload release	√				√
Dynamic braking		√			√
Back stopping		√			√
Intermittent Operation On-off, with driver at speed	√				√
Inching and jogging	√				
Indexing and load positioning					√
Dual-drive and Standby Operation		√			√

a predetermined rate when the prime mover has attained a pre-established speed.

• **Continuous slip.** Designed for operation with the input shaft operating at one speed and the output shaft at another. Two classes of operation are involved: (1) clutch slips automatically to maintain torque at an established value; (2) degree of slip can be controlled externally while the machine is running.

• **Overrunning or freewheeling.** Used in a number of specialty applications.

For selection purposes these categories are ranged in Table 1 against a list of primary clutch functions. Tables 2 through 5 break the general "kinds" down into the basic clutch types they comprise, and offer a comparison of these types on a number of critical criteria. Tables 6 and 7 direct you to typical manufacturers, as specified by the principle employed to transmit torque and the mode of control.

Here is how to use the tables:

Step 1. List the functions that the clutch in your system will have to perform. Check this list against Table 1 to determine which general kind of clutch best meets all of your requirements. Note also any category that can do almost as well—it may offer an alternative solution to your problem.

Step 2. Proceed to the table for the kind of clutch you

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II—COMPARISON OF UTILITY CLUTCHES

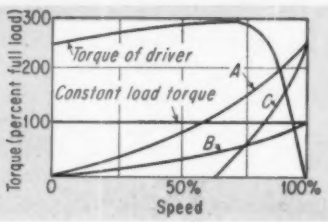
	Capacity Range, hp at 100 rpm	Max Engagement Speed, rpm	Max Running Speed, rpm	Shaft dia, in.	OD, in.	Idling-drag Torque	Relative Cost, (within class)
Positive Contact							
Square jaw	1–260	2–10	——	15/16–6	3–15	Very low	1
Spiral jaw	1–260	2–10	——	15/16–6	3–15	Very low	1
Tooth	——	300	3700	1¼–6½	4–20	Very low	1–10
Friction Clutches							
Axial types							
Single disk	0.2–660	——	3000	3¼–9⅞	4–56	Low	1–10
Multiple disk	0.01–2670	——	5200	3¼–9⅞	4–56	Low	1–10
Radial Types							
Expanding	0.5–125	——	1800	1–6 7/16	5–27	Low to moderate	5
Contracting	1–560	——	Low	2½–5	24–54	Very low	2 to 10
Expand-contract	1–480	——	Low	2–7¾	15–64	Moderate	2 to 10
Cone or V-belt	——	Same as plain pulley	——	½ to 1½	2 5/16–5	Low	Low

IV—COMPARISON OF CONTINUOUS SLIP CLUTCHES

	Capacity		Speed, rpm	Type of Load			Min Slip, %	Shaft or Bore Size, in.	OD, in.	List Cost (units of $100)
	HP	Torque, lb-ft		Variable Torque	Constant Torque	Constant Tension				
Friction Clutches Mechanical (adjustable while running)	——	24 to 10,500	up to 1800	——	——	√	0	¾ to 8	5¾ to 27	1.7 to 58
Electrical	4 to 5200	to 140,000	100 to 5000	√	√	√	0	⅞–6⅝	4½ to 84	0.5 to 15
Pneumatic Axial (airtube)	3.5 to 2600 (100 rpm, 100 psi)	to 140,000 (100 rpm and 100 psi)	500 to 1800	√	√	√	0	1¾ to 10	9 to 52	5 to 15
Radial Expanding Airtube	18 to 360 (100 rpm, 75 psi)	1.5 to 30,000 (100 rpm and 75 psi)	——	√	√	√	0		12 to 35	5 to 15
Shoe	——	880 to 245,000 (100 psi)	480 to 1165	——	——	√	0	1 15/16 to 4	15 to 40	15
Contracting Airtube	3-1750 (100 rpm, 75 psi)	150 to 90,000 (100 rpm, 75 psi)	——	√	√	√	0		10 to 96	5 to 15
Automatic Slip Clutch	——	10–6300	——	√	——	——	0	½ to 4⅞	3 to 20	0.2 to 10
Magnetic Clutches Magnetic Particle	——	up to 100	up to 1000	√	√	√	0	¼ to 10	2 to 10	——
Electromagnetic	3–310	——	0–1740	√	√	——	2–5	1¼ to 2⅞	17¾ to 32½	15
Permanent Magnet	1.7 to 12.7	3 to 30	to 1800	√	——	——	1–5	⅞ to 3½	8⅞ to 12½	3
Fluid Hydraulic	(See Table 3)						1–6	——	——	——

III—THE TYPES OF SELF-ACTUATING CLUTCHES
(Includes comparison with utility clutches for accelerating load)

	Capacity Starting hp (higher than running)	Speed Range, rpm max	min	Slipping Speeds	Accel. Curve (below)	Shaft or Bore, in.	OD in.	List Cost, $
Centrifugal								
Variable pulley	up to 10 (at 3000 rpm)	over 3000	1800	0 or preset	A or C	½ to 1 1/5	2 to 7⅜	5 to 30
Free shoe	up to 1350	10,000	500	very low	A	½ to 3¼	3 to 25½	40 to 2800
Restrained	up to 1350	10,000	550	preset	C	¼ to 3¼	3 to 33	15 to 3250
Mercury	———	5000	900	preset	C	¼ to 2⅝	3 to 10	8 to 110
Trailing shoe	up to 600 (at 590 rpm)	4000	low	0	B	1¼ to 8	4¾ to 33	40 to 3250
Friction band	up to 290 (at 1450 rpm)	1750	380	preset	A	1⅝ to 4⅝	6¼ to 17½	50 to 200
Fluid Couplings								
Dry fluid	up to 1000 starting up	1800	500	0	A or B	½ to 3⅜	5 to 18	80 to 1000
Hydraulic	———	1800	750	0	A or B	1 to 2⅞	12 to 22	50 to 200
Utility Clutches								
Straight slip	See table 2	——	——	———	C	See table 2	———	———
Electromagnetic	See table 4	1800	low	0	A or B	See table 4	———	———



A=Normal free acceleration curve
B=Delayed acceleration curve
C=Extended acceleration curve

V—OVERRUNNING OR FREE-WHEELING CLUTCHES

	Capacity		Overrunning speed, rpm	Idling drag	Shaft or bore dia, in.	OD, in.	List Cost (units of $100)
	Hp	Torque, lb-ft					
BALLS OR ROLLERS							
General Duty	1/20 to 394 (100 rpm)	2.5 to 20,500	3600 to 65	Very low	⅜ to 8	2 to 25	0.5 to 65
Single Revolution	0.4 to176 (100 rpm)	2 to 9250	500 to 65	Very low	¼ to 5	1¼ to 17½	0.5 to 28
SPRAGS AND CAMS							
General Duty	0.15 to 48 (100 rpm)	4.5 to 136,500	3450 to 40	Very low to moderate	¼ to 12	1¼ to 28¾	0.7 to 30
Single Revolution		8 to 8000	Same	Same	Same	2 to 17	0.7 to 30
SPRINGWOUND							
General Duty or Single Revolution	1/50 to 20	8 to 1250	3600 to 1000	Moderate	⅛ to 1	½ to 2⅞	0.03 to 0.4

have selected, and compare the performances and ranges of the different types available, referring to the accompanying text for details.

- Table 2 covers Utility Clutches
- Table 3 covers Self-Actuating Clutches
- Table 4 covers Continuous Slip Clutches
- Table 5 covers Overunning or Freewheeling Clutches.

Pick the basic type that appears best for your application.

Step 3. Move on to Table 6. Locate the basic type you have chosen by principle of operation and mode of control, and translate the key number that appears at their intersection by referring to Table 7.

DESCRIPTION OF CLUTCH FUNCTIONS

Starting

No-load starting permits the prime mover to accelerate without the drag of full load. The prime mover is protected from overheating, and the entire transmission system is protected from strain.

Manual or other external control permits the load to be applied at will, and the drive can be idled indefinitely without danger to the clutch.

Automatic no-load starting eliminates operator error. It starts the load at exact moment when prime mover has attained efficient speed.

Smooth load pickup

With the proper clutch, the load is accelerated gradually and easily, without torsional shock.

Normal loads, where starting torque requirements are low, are brought up to running speed rapidly but smoothly. Clutch must slip just enough to protect the system from major shock loads.

High-inertia loads must be brought up to running speed smoothly. For automatic starting the load may be accelerated slowly after the prime mover is at normal speed. Typical loads include centrifuges, flywheels, machine tools.

High-breakaway loads may require 100% or more of the running load just to overcome initial friction. But high breakaway load does not build up sufficient momentum to damp out torsional fluctuations, and the acceleration may be irregular.

Automatically delayed pickup allows engines and turbines to start and warm up at a predetermined idle speed before load is applied. For high starting-torque loads, "inertia delay" lets an electric motor come up to synchronous speed before taking on the load. The method is useful in dual-drive and standby applications, automatic washers, air compressors, vacuum pumps.

Extended acceleration may be required for slowly and gently accelerating delicate and breakable materials. If a friction clutch is used the effect of transient variations in coefficient of friction need to be carefully controlled.

Auxiliary starter and booster motors must generally be clutched in and out of operation rapidly. The clutches should be self-actuating, sensitive, fast. Typical applications: starters for reciprocating engines or gas-turbines.

Running

Normal loads operate at reasonably constant torque and speed. Clutch couples prime mover to load, without slipping.

Control of a variable-torque load requires a clutch designed for constant slip so that load speed matches changing torque demands. Characteristic curve for such a load is shown in top chart, p 43. Torque load varies proportionately with square of the speed of the driven equipment, and horsepower varies with cube of speed.

Control of a constant-torque load requires a clutch designed for constant slip and torque delivered to load.

Control of a constant-tension load requires a clutch designed for constant slip and constant horsepower regardless of speed; torque will vary inversely with load speed.

Overload protection and stopping

General protection is required where overloads will be transient and infrequent. Function of the clutch is to slip, relieving sudden inertial loads if the machine seizes.

Limit torque. Required where frequent and prolonged overloads are anticipated. The clutch must be able to handle heavy slip.

Limit speed. Clutch acts as an automatic brake that holds load speeds within safe limits. Driven member of the clutch may be attached to a stationary housing, with the clutch set to engage at some maximum speed. Typical applications: elevators, garage doors, hoists or lift trucks.

Automatic overload release. The clutch here should disengage, not slip, so all power is removed from load.

Dynamic braking. Clutch function is to accept instantaneous reversal—to bring a heavy load to a cushioned stop, so that the motor can reverse and return to operating speed quickly while the load is accelerated gradually.

Backstopping or holdback. Clutch prevents reverse rotation of the load. Normally driving member is attached to the rotating part to be controlled; other member anchored. Shaft is free to rotate in one direction, but the clutch locks up instantly if the shaft reverses.

Intermittent (on-off). Function of clutch is to connect and disconnect the load while the prime mover continues to operate at speed. Example: a continuously running motor stores energy in a flywheel; clutch delivers this energy during the working stroke of machine.

Inching and jogging are primarily manual operations. The clutch is only briefly and tentatively engaged, so that load turns a little, but is not accelerated to operating speed.

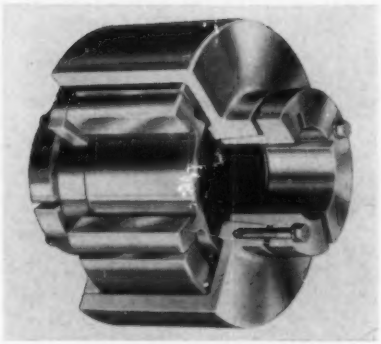
Indexing and load positioning. Indexing consists of the unidirectional, incremented advancement of the load. Here, the clutch translates a continuous motion into intermittent rotary or linear motion.

Utility clutches

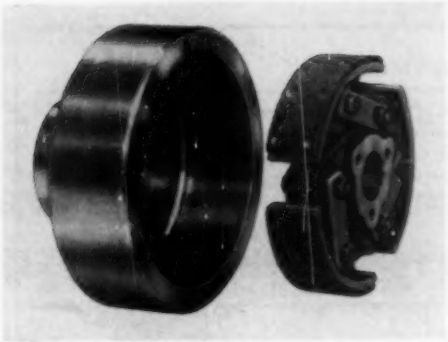
Here, "utility clutches" include all positive-contact types and most friction clutches that are not self-actuating. Some externally controlled friction clutches may be considered either utility clutches or variable slip clutches, depending on the controls employed.

Positive-contact clutches are generally cheap, uncomplicated, relatively sturdy. They offer high torque capacity for their weight and size. Application is limited by low engagement speed—about 60 rpm max for jaw clutches, 300 rpm for specially hardened tooth clutches—and the absence of slip. Load is applied with considerable shock, torque transients cannot be cushioned, and operation frequently is noisy.

For a positive lock between high-speed shafts hybrid



Free shoe centrifugal clutch, Formsprag Co



Restrained shoe centrifugal clutch. Can adapt either for leading or trailing shoe operation. Hilliard Corp

clutches combine a tooth clutch with a multiple-disk friction clutch which slips to reduce the relative speed between the shafts for safe engagement.

Friction clutches offer cushioned load pick-up and overload protection, but raise problems of heat dissipation, and size is critical. Dozens of standard varieties are available with many combinations of alternative features.

Radial types are usually simple and inexpensive, but most are limiited to comparatively low speeds: centrifugal force makes it difficult to disengage expanding-shoe types, and to maintain engagement of contracting-band types. Springs used to overcome this disadvantage adds to the operating force.

Axial types are little affected by centrifugal force but mean friction radius is smaller, and shift mechanisms frequently take up considerable room.

Self-actuating clutches

This category includes automatic friction clutches and fluid couplings. They are used primarily for automatic load pick-up and overload protection, though some types are also helpful in speed-limiting and back-stopping.

For electric motor drives these clutches can decrease load acceleration time and limit motor starting current so inexpensive standard squirrelcage motors can be used instead of special high-torque motors. They also permit across-the-line starting without expensive reduced voltage starters. The drive motor can usually be selected on the basis of running power alone.

For internal combustion engines, these clutches permit gradual application of load while the engine runs at normal speed. Some specialized centrifugal clutches have been developed for standard engines up to about 10 hp, and a number are concentrating in the "karting" field, with lines of automatic transmission packages for "go-karts," golf carts, power mowers, and the like.

Centrifugal clutches exploit some half-dozen operating principles to obtain three basic acceleration curves.

Variable-pitch V-belt pulleys open and close through governor-driven internal linkages. The "clutch" can consist of a single pulley or a pair in which one opens as the other closes. The belt itself, is the only part that can overheat on overload and it is exposed to the air for good heat dissipation.

Free-shoe centrifugal clutches simply have weighted friction shoes thrown into contact with the driven member as the driving member picks up speed. Clutch will slip continuously until its torque is equal to torque of the prime mover. From this point, acceleration follows the speed-torque curve of the motor to 100% full-load torque.

Some types have two sets of shoes: an outer set carried in the driving member, and an inner set on the hub of the driven member; as the driven half comes up to speed, its set engages the inner surface of the driving member to boost torque capacity by 40%.

Restrained-shoe clutches are similar, but the shoes are spring-loaded to resist centrifugal action, so that the driving member is accelerated to a predetermined speed before the clutch begins to slip, at which point its torque builds up rapidly.

A variation on spring restraint employs the torsional action of heavy-duty rubber bushings to resist the centrifugal impulse on the shoes. This method eliminates loose mechanical joints and lends a limited flexible coupling and shock absorbing capability. It also permits normal "leading shoe" operation in one direction of rotation, and "trailing shoe" operation in the other.

If the shoes lead the hub to which they are linked, the drag between the drum and the shoe creates a self-energizing action to speed power transmission. If direction of rotation is reversed, the shoes trail the hub and power buildup is extremely gradual—a function solely of the speed of rotation.

Trailing-shoe clutches, therefore, offer only about 25% the capacity of leading-shoe units of the same size, but they give a much closer control of slip and permit the use of maximum lining areas. In these units, the "apparent" coefficient of friction between shoe lining and the drum is little affected by transient variations in the actual coefficient.

Friction-band clutches (sometimes called slipring starters) employ long, flexible shoes fastened at one end to a rotating spider to obtain a closely controlled wrapping friction. They offer extremely tight slip regulation, and are little affected by changes in the actual coefficient of friction.

Mercury clutches are operated indirectly, by pressure developed by centrifugal force in a mercury-filled rubber gland.

continued, next page

SELECTING CLUTCHES continued

VI—TYPES OF CLUTCH AND REPRESENTATIVE SUPPLIERS

(numbers refer to list of manufacturers in Table VII)

	CONTROL OF ENGAGEMENT				SLIP	
	Mechanical	Electrical	Pneumatic	Automatic	Variable	Preset
Clutch Type	POSITIVE CONTACT					
Square	21, 28, 30					
Spiral Jaw	21, 28, 30					
Gear Tooth	3, 7, 21, 26	4, 9				
	FRICTIONAL CONTACT					
Variable-pitch Pulley	36, 40			37, 41 (Note 1)		(Note 2)
Radial (all types)	11, 12, 21, 26		12, 18, 25	2, 6, 10, 11, 12, 20, 24, 27, 37 (Note 1)	12, 18, 25	(Note 2)
Axial (friction plate or disk)	1, 5, 6, 7, 11, 12, 15, 16, 25, 26, 30, 31, 34	4, 14, 18, 34, 39, 42	11, 15, 25, 26, 43	35, 37 (Note 1)	24, 25, 42, 43	6, 16, 24 (Note 2)
Cone	23, 26					19 (Note 2)
	OVERRUNNING OR FREEWHEELING					
Cam (roller or sprag)	6, 8, 11, 20, 24, 40 (Note 2)			6, 8, 11, 20, 24, 38		
Spring-wrapped	13, 33			13, 33		
	MAGNETIC COUPLING					
Magnetic particle		29, 34			29	
Eddy current		17		22	17	22
	FLUID COUPLING					
Dry				15		
Hydraulic	32			12, 33	32	32

Note 1: Centrifugal clutches

Note 2: All friction clutches will slip during acceleration and overload, only types designed primarily for extended slip operation are noted here.

Continuous-slip clutches

Heat dissipation is of primary importance in all clutches needed for frequent or continuous-slip operation. Most of these are constructed with special thermal paths to conduct heat away from critical parts, and many are ventilated. Electromagnetically controlled clutches may require nonstandard high-temperature coil insulation for such operation.

As the friction surfaces of continuously variable adjustable-while-running clutches wear, the torque capacity of mechanically controlled types decreases; that of pneumatically controlled types remains the same; and that of electrically controlled types increases, because airgaps are diminished.

Eddy-current clutches of the permanent-magnet type can take instant reversals. They permit using the drive motor as a dynamic brake.

NOTE: Companies listed above include the many who generously supplied details for this article. The list should not be regarded as complete. Also, inclusion of a company name here does not necessarily endorse its product, just as omission does not imply an inapplicable product.

For REPRINT of above article, just check 611 on one of the Reader Service cards found in this issue.

VII—REPRESENTATIVE CLUTCH MANUFACTURERS

1. Auto Specialties Mfg Co, St Joseph, Mich
2. Automatic Steel Prod., Mercury Clutch Div, Canton 6, Ohio
3. A Y Dodge Co, Rockford, Ill
4. Bendix Corp, Eclipse Machine Div, Elmira, NY
5-8. Borg-Warner Corp
   5. Borg & Beck Div, Chicago 38
   6. Morse Chain Co Div, Ithaca, NY
   7. Rockford Clutch Div, Rockford, Ill
   8. Spring Div, Bellwood, Ill
9. Carlyle Johnson Machine Co, Manchester, Conn
10. Comet Industries, Richmond, Ind
11. Conway Clutch Co, Cincinnati 25
12. Crofts U S A Inc, Chicago 45
13. Curtiss-Wright Corp, Marquette Div, Cleveland 10
14. Cutler-Hammer Inc, Milwaukee 7
15. Dodge Mfg Co, Mishawaka, Ind
16. Edgemont Machine Co, Dayton, Ohio
17 Electric Machinery Mfg Co, Minneapolis 13
18. Fawick Corp, Fawick Airflex Div, Cleveland 11
19. Flaton Machine Works Inc, Lemay 26, Mo
20. Formsprag Co, Warren, Mich
21. Gear Specialties Inc, Chicago 47
22. Gleason Reel Corp, Tormag Products Div, Milwaukee 3
23. Haller Inc, Northville, Mich
24. Hilliard Corp, Elmira, NY
25. Horton Mfg Co Inc, Minneapolis 14
26. Industrial Clutch Corp, Waukesha, Wis
27. J P Madden Inc, Bethlehem, Penna
28. Jeffrey Mfg Co, Columbus 16, Ohio
29. Lear Inc, Electro-Mechanical Div, Grand Rapids 2, Mich
30. Link-Belt Co, Chicago 1
31. Lipe-Rollway Corp, Syracuse, NY
32. Liquid Drive Corp, Holly, Mich
33. Machine Components Corp, Jericho, NY
34. Magtrol Inc, Buffalo, NY
35. Novo Industrial Corp, United Specialties Div, Chicago 28
36. Reeves Pulley Co, Columbus, Ind
37. Salsbury Corp, Los Angeles 1
38. Scully-Jones & Co, Chicago 8
39. Stearns Electric Corp, Milwaukee 2
40. V-Belt Clutch Co, Los Angeles 4
41. V-Plex Clutch Corp, Hagerstown, Md
42. Warner Electric Brake & Clutch Co, Beloit, Wis
43. Wichita Clutch Co, Wichita Falls, Tex

why we need

NON STANDARD RATINGS FOR INTEGRAL-hp MOTORS

Conditions have changed in the 30 years since NEMA standardized motor ratings. Now it's time to take another look at these standards. For example, between 5 and 10 hp, wouldn't it help to have a 6¼ and an 8¾ in addition to the standard 7½?

JAMES MORRISON
Reuland Electric Co, Western Div
Alhambra, Calif

Here is a familiar situation. Suppose the application calls for a motor, gear case, and coupling–and space is critical. Say the known load is 3.7 hp. So you must use a 5-hp motor, even though the gearbox you had in mind has a mechanical rating of only 4.3 hp. Of course, the next size gearbox would do the job, but it is much too large for the space. Meanwhile, the larger shaft size demands a larger, more expensive coupling. And with each oversize component, the price jumps upward. Wouldn't it be a neat answer if you could specify a 4-hp motor, with gearbox and coupling to match?

In other words, wouldn't it be handy to bring NEMA standards for integral motors up-to-date. The National Electrical Manufacturers' Association standards for horsepower ratings were established more than 30 years ago—in days of line shaft and flat belt. Today, with every machine separately powered and sometimes each function of a machine having its own motor, an increasing number of applications require motors with intermediate ratings. The accompanying table shows existing NEMA standards, plus some suggested intermediate ratings that would be helpful.

Modifying any long-established standard is not a simple task, and NEMA standards are no exception. By the time enough people are convinced that the change is important, and the change then is thrashed out in the trade associations, years can pass.

A practical solution

My company's approach to the problem is to offer intermediate ratings with the anticipation that other manufac-

NEMA STANDARDS, 1 to 60 hp. WITH SUGGESTED INTERMEDIATES

	HP	Frame Size	Dia, in.	Length, in. (Including shaft)	Shaft Dia, in.
	1	182	9	12	⅞
	1½	184	9	13	⅞
	2	184	9	13	⅞
√	**2½**	**213**	**10½**	**15½**	**1⅛**
	3	213	10½	15½	1⅛
√	**4**	**215**	**10½**	**17**	**1⅛**
	5	215	10½	17	1⅛
√	**6¼**	**215**	**10½**	**17**	**1⅛**
	7½	254U	12½	20	1⅜
√	**8¾**	**256U**	**12½**	**22**	**1⅜**
	10	256U	12½	22	1⅜
√	**12½**	**284U**	**14**	**24**	**1⅝**
	15	284U	14	24	1⅝
√	**17½**	**286U**	**14**	**25**	**1⅝**
	20	286U	14	25	1⅝
√	**22½**	**324U**	**16**	**26**	**1⅞**
	25	324U	16	26	1⅞
√	**27½**	**324U**	**16**	**26**	**1⅞**
	30	326U	16	28	1⅞
√	**32½**	**326U**	**16**	**28**	**1⅞**
√	**35**	**326U**	**16**	**28**	**1⅞**
√	**37½**	**326U**	**16**	**28**	**1⅞**
	40	364U	18	29	2⅛
√	**45**	**365U**	**18**	**30**	**2⅛**
	50	365U	18	30	2⅛
√	**55**	**365U**	**18**	**30**	**2⅛**
	60	404U	20	33	2⅛

Note: Frame size and dimensions are for 4-pole ac, foot-mounted motors.

turers will follow, and thus establish an informal standard. A good example of this approach took place recently. One manufacturer developed a "pancake" motor, admirably suited to milling-machine drives and other machine-tool applications. It was followed by a "wafer" design in a conventional airgap motor. The redesign was subsequently built by four or five more manufacturers. As each entered the field, he designed his product with the same bolt circles, shafts, etc., as the original motor, in an effort to obtain a share of the existing business as well as participate in a growing market. The result is an informal standard, which is widespread and will undoubtedly be adopted by the standards association of the industry.

The intermediate-horsepower ratings can be readily manufactured in the existing standard-frame sizes. The savings resulting from a closer match to application requirements, both in initial cost and operating economies, will more than offset the extra cost resulting from engineering new designs and maintaining larger inventories.

Practical applications

The crane industry has used intermediate-horsepower ratings for many years. Why? Because performance of a crane depends upon a close relationship between required and delivered torques to ensure good acceleration and speed-control characteristics. Therefore two or three of the largest crane manufacturers in the US make their own electric motors.

Wound-rotor motors provide poor regulation when not properly sized to the load, yet the same type motors used in cranes—therefore closely sized—achieve 70 to 75% regulation with conventional controls. And with the new static controls they achieve almost 100% regulation.

A specific instance demonstrating the value of intermediate ratings where a number of motors is required is seen in an evaluation of a special drilling machine which showed that it could have been powered with four 4-hp motors instead of conventional 5-hp units. Total connected rating could have been reduced from 20 to 16 hp. This would decrease installation cost substantially because both feeder and protective switch could be reduced one full size. Continuous savings would be realized by the lower total connected horsepower, which is generally calculated into final power cost in existing rate structures of power companies.

Examples of cost reduction

If you have a load requiring 34 or 35 hp, an intermediate-rating motor of 35 hp (364 U frame size for 6-pole motor) will save you about $70 in cost of motor and coupling when compared with using the next standard size, which is 40 hp (404 U frame size). And it will measure 25½ in. long by 17⅛ in. high instead of 37 in. long by 21 in. high.

An 8-hp load could use an 8¾-hp motor instead of the standard 10 hp and you would save $9.40 in cost of motor (here, space occupied will be the same).

For a 3½ to 4-hp load, a 4-hp intermediate motor would cost $5 less than the standard 5-hp, and the gearbox would cost $20 less. The gearbox would be 2 in. less in height and 4 in. less in length.

EDITOR'S NOTE: For more information on revision of NEMA ratings, see:

NEMA Standards for Those Size-reduced Motors with the Same Power, Feb 3 '58, p 54—Compares new frame standards with old, for motors from 40 to 125 hp.

These three articles summarize progress of NEMA motor rerating program:

What the New NEMA Standards Mean, Dec '53, p 144; **NEMA Rerate Motors,** Nov '55, p 195; **NEMA Standards for DC Motors and Generators,** Mid-Oct '56, p H-10.

—Frank Hall

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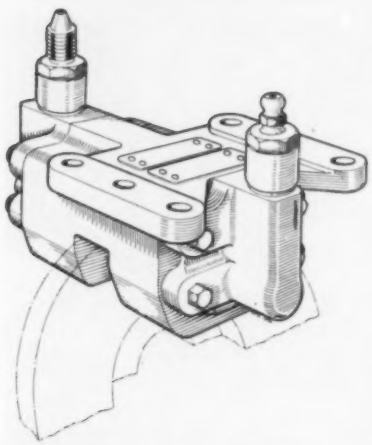
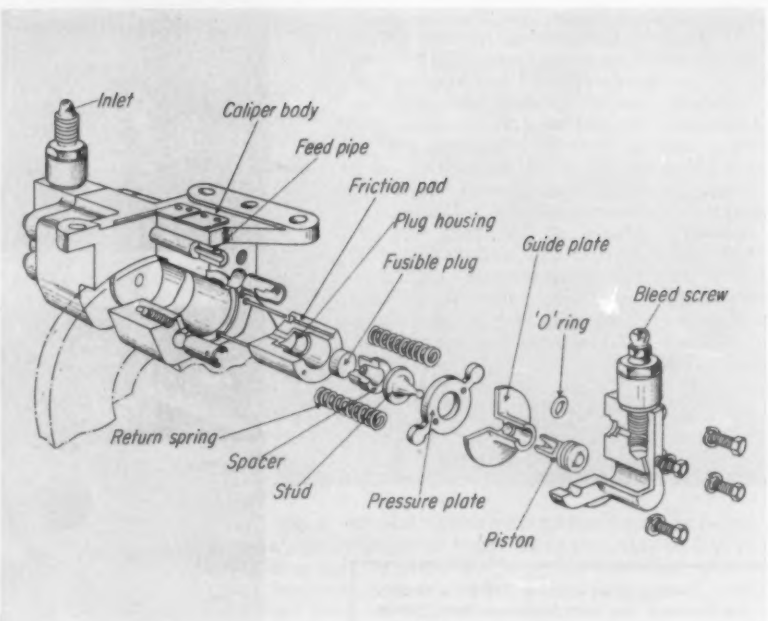


PISTON-ACTUATED friction pads are mounted in a caliper body which straddles a disk mounted on the propeller shaft. When hydraulic pressure is applied to the pads the disk is squeezed between the friction pads to stop the propeller. Fusible plug prevents damage or power loss should brake be applied above mandatory propeller speed. Brake is normally applied on ground after fuel to the engine is cut and engine rpm begins to drop. Interlocks prevent brake from being applied when engine is under power; they also prevent engine from being started when brake is applied.

PS . . . Hydraulically operated brake will stop a turboprop propeller in 20 sec and hold it in a 50-knot wind. This eliminates danger of ground crews being struck by propellers windmilled by wind gusts and allows passengers to disembark more quickly. Prop-brakes are fitted to Handley Page Herald (shown), Vickers Vanguard and Grumman Gulfstream. Brake is produced by Dunlop Rubber Co Ltd, Foleshill, Coventry, England. —N. Landon



FUSIBLE PLUG is a link in the mechanical connection between the hydraulic actuated piston and the friction pad. When the plug melts, this breaks the link between piston and friction pad, allowing the return springs to withdraw the pad.

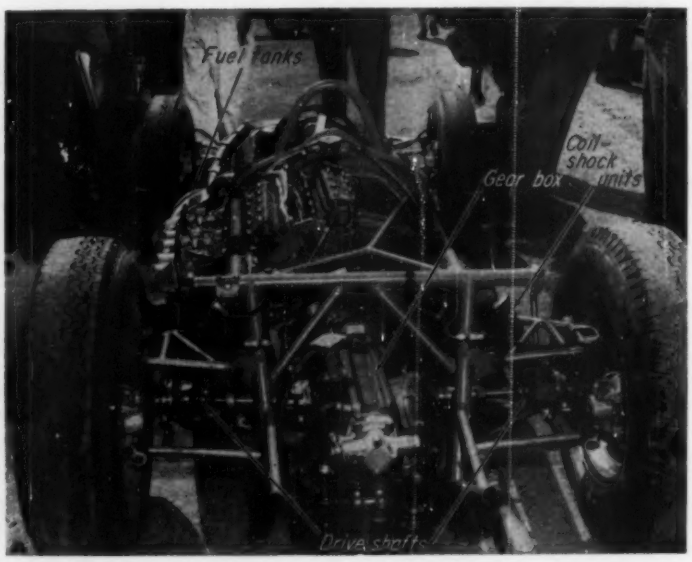
When hydraulic pressure is applied to the piston it is transmitted to the friction pad through the stud, spacers, fusible plugs and plug housing. Return springs are compressed by the ears on the pressure plate, which is riveted to the friction pad. Overheating during operation melts the fusible plug. Its metal then flows through the central hole in the spacer. Since total piston travel is less than the thickness of the fusible plug, escape of the molten metal permits the return springs to withdraw the pressure plate and attached friction pad to the inoperative position.

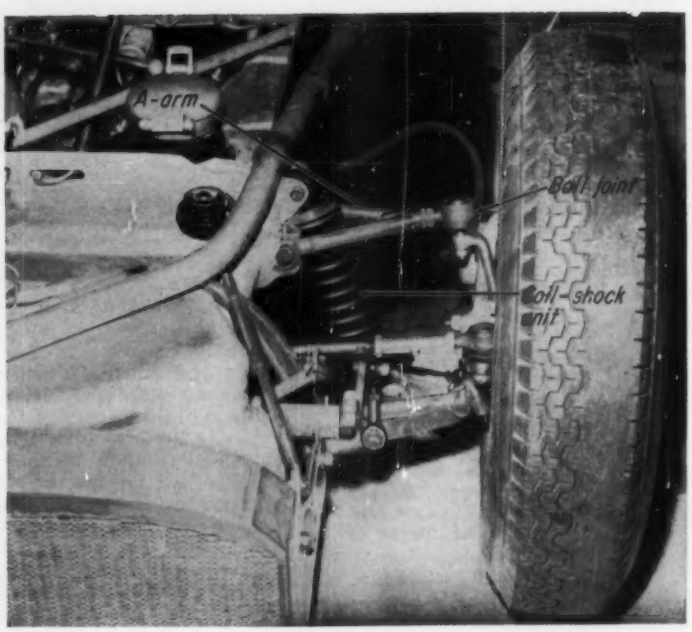
INDIANAPOLIS 61:

Racing Cars – Anything New?

Contrasting with the usual cautious designs among the qualifiers was a unique import with rear engine and independent suspension—the British Cooper.

ENGLISH-BUILT Cooper with 92.5-in. wheelbase, first successful foreign qualifier in 9 years, did it at an average speed of 145.144 mph. It's basically similar to successful European road-racing Coopers except that its engine is canted 14° to the left, to provide a favorable weight balance on the Indianapolis anti-clockwise track. In addition, the entire chassis was offset approximately 3 in. to the left (note unequal length of driveshafts to the rear wheels). Suspension is independent, with coil springs at each wheel, enclosing a tubular shock absorber. Unlike most Indianapolis cars it uses carburetors rather than fuel injection. The 3-speed transmission is another difference that may help in the turns—others have one or two speeds forward and rely on the tremendous torque of their Meyer-Drake (Offenhauser) engine for acceleration. The Cooper, scaling 1000 lb, weighs in 600 lb under other entries, so is competitive on a power-weight basis. Dual-over-head-camshaft Coventry Climax engine has a 167-cu in. displacement, produces 250 hp. Fuel load, on either side of driver, is located on center of gravity. This eliminates problem of shifts in polar moment and weight distribution that cars with tail-mounted tanks encounter. Driver sits in semi-reclining posture to lower frontal area.

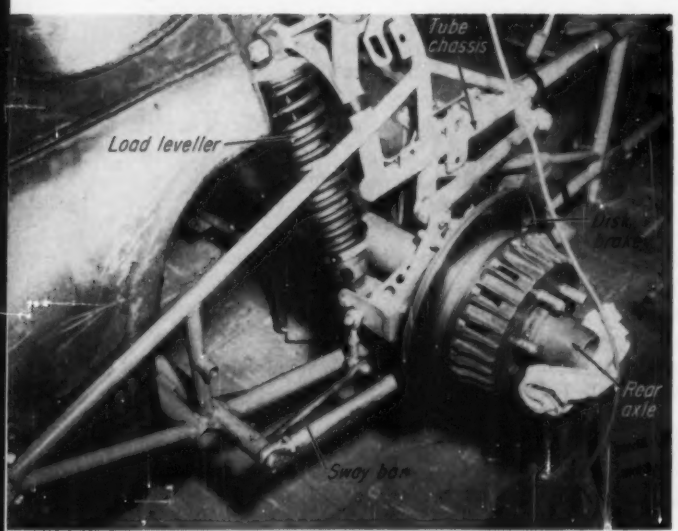




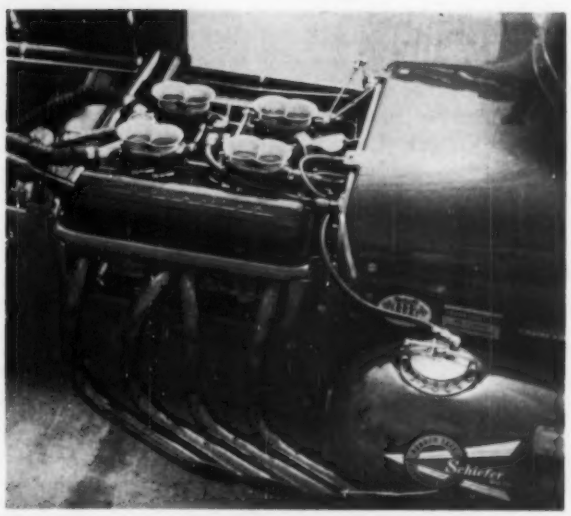
PS . . . Although its sporting interest is terrific, the Memorial Day race introduces little that is really new in design. Principal reason for the lack of innovations among racing cars is three-fold: 1) the poor reliability record of past innovations; 2) desire not to gamble with so big a purse; 3) cost of building and running a possible winner ($40,000-50,000). Most of the cars in this year's race followed the pattern which has become the standard since World War II:—a tubular chassis with solid axles front and rear, torsion bar suspension, and Meyer-Drake 4-cyl engine. Notable exception was the up-to-the-minute English-built Cooper. This modified version of a road-racing car has been successful in European competition for several years. —Donald MacDonald

HIGH-PRESSURE FILLING SYSTEM keeps all fuel enclosed in either the hose or the car's tank. The quick-disconnect hose is connected to the lower opening, and fuel will not flow until the fitting is tight. Nitrogen pressurized-supply containers transfer 40 gallons of fuel in 20 seconds. Filler holes at the top are used for venting and to check fuel level. A pressure cutoff on the hose, similar to that used by most service stations, halts fuel flow. Filling through the top is dangerous because spilled fuel pours over the hot exhaust pipe. In split-second pitwork, four men change all 4 tires, fill the fuel tank, clean the windshield and give a drink of water to the driver, who remains in the car.

DEEP-DISH STEERING WHEEL, relatively new to Indianapolis, is a safety feature, as is the mandatory crash pad over the steering wheel hub. Instrumentation is primarily for practice and tuneup; during the race drivers are too busy to watch them. In any case, drivers would run cars until engine actually failed since instrument malfunction is common under the severe vibration and shock conditions encountered.



INGENIOUS SOLUTION to the suspension problem is Monroe's simple adaptation of a commercially available "Load Leveller" used to keep heavily loaded passenger cars level. Spring rate is 190 lb at front and 210 lb at the rear; travel is 4 in. front, 5 in. rear. Car's builder, A. J. Watson, saved 100 lb per car over the typical conventional torsion-bar suspension system. Each suspension unit weighs 11 lb, and Monroe engineers say that next year, when there is a chance to design a unit especially for this race, the weight will be cut to 7 lb.



THE ONLY "STOCK"-ENGINED CAR attempting to qualify used a Chevrolet power plant. After two tries (it had to do 144.2-plus mph to make the race, but managed less than 142) this model was ruled off the track as a hazard to other drivers. Some yet unexplained mixup in converting the stock engine to a dry-sump lubrication system caused oil to flow from the exhaust headers. One of the three engines tried used chemical milling to bring weight of engine down to about 300 lb with aluminum heads. Stock displacement of 283 cu in. was reduced to the Indianapolis formula of 256 by steel sleeves. Alterations included roller cam followers, forged chrome-vanadium connecting rods, forged aluminum pistons, and moly bearing caps. Hilborn fuel-injection system was abandoned in favor of four carburetors. Two-inch exhaust valves, 1⅝-in. intakes were used; the counterweighted crankshaft was machined from a solid billet. Prime reason for the Chevrolet engine was to save $10,000, but the modified passenger-car engine could not stand up to the pace set by other qualifiers.

how to listen... and remember

1..THREE SIMPLE STEPS...AND WHY TO TAKE THEM

2..TEN WAYS TO BE A BAD LISTENER

3..NOTE-TAKING...HOW AND WHY

Notes can do three major things for you:

1. **Help you learn more—and faster.** They help you analyze and evaluate the idea content of what you're hearing, they help to impress the noted idea on your mind because you write it, they force your active participation.

2. **Help you remember more—and longer.** They remind you of the 75% you'd otherwise forget, thus providing a memory storage, review and recall device. They can parlay their reference value to you by triggering other ideas.

3. **Help you study and work more efficiently.** They save time and trouble in recall or review, clear your mind of detail, provide insurance that eases your mind.

There are two basic forms of note-taking, the **narrative summary** and the **outline.**

The **narrative summary** is a restatement in your own words of the gist of what has been said. It is particularly useful in discussion or conferences, or when listening to a speaker who touches upon a number of subjects, covering none in depth. (It is also helpful in taking notes on reading from several references or on several topics.) It makes no effort to evaluate the discourse by major and minor points or place them in an organized order.

The **outline** is a more formal approach, organizing the heard material with main and subheads. It is preferable for "depth interviews" and detailed material, easier to think through and select from later, a better style for all-around use, harder to do originally. It can be either **formal** or **informal,** the first being quite rigid, and including number and letter subdivisions, the other merely statements in classified order. The latter method is faster and can often be done without rework—if the speaker himself is organized. If you have prior knowledge of the speaker's points, it may be well to take notes on properly headed cards or sheets which can be shuffled into more useful order later.

Notes are preferably made in your own words unless you intend to quote the speaker directly somewhere. Your own words are more useful, because they utilize your own vocabulary. The change in wording also makes you think while you're recording, also requires active participation, so you learn faster. Both are important in the memory process—an actor learns better while walking through and "feeling" his part than with just a script.

Familiar wording helps in review as well, because it may assist you in reconstructing the original session. It also helps if you must convey the ideas to others; what you say will sound convincing and like you—not as if you were parroting someone else. But beware of one thing—**don't change the idea when you change the words.**

Notes should be brief, but not too brief; follow the old formula for a woman's skirt: "Long enough to cover the subject, short enough to be interesting." You can be so terse that your notes are telegraphic and subject to later misinterpretation—unless you're quoting the speaker precisely. In that case, you can drop the short words; otherwise you'd better not drop such words as *a, the, from, to, for, and.* Major changes in meaning can result if you paraphrase the speaker and drop the short words too.

Remember to check back over your notes shortly after you've made them. This will reinforce your memory gaps, help you to learn, and pick up the places where your mind or your pencil strayed. Poor notes become useless when they're "cold" as well. As you reread, hunt for the gist, for "quotable quotes" that make the points clearly and quickly, for key phrases and sentences. Hunt for related ideas, for examples and illustrations that the speaker used to clarify his points. A 2-step rereading is often helpful, first at the "glance" level, next at the study level.

If you want to get the most out of a difficult subject, prepare in advance. Read up any available material, get copies of earlier papers of the same man if you can.

When you arrive at the hall, choose a good location—not too close and certainly not too far back. Be sure the light is good, and that you'll be able to hear without strain. Have a good writing surface—briefcase, piece of plastic, several pads with backs. Obviously be sure you have several writing implements. (If you take notes in pencil, interlining in ink will be much more clear, and vice versa.) Label and date your notes.

During the talk, listen for "cues"—expressions like: "The most important . . .", "first . . . second . . . third," "finally" (often a blessed word), "in summary," "most successful was . . ." Also watch for contrasts and comparisons: "on the other hand . . ." "besides," "on the contrary," "moreover," "however," "furthermore." The parenthetical ideas that follow such words may put flesh on a skeletonized idea.

As you take notes, flag important points—by underline, asterisk or other device. Listen for any special instruction that may limit the usefulness of what you're hearing.

Editor's Note—Reprints of this series will be available as a free 4-page booklet. Simply circle the number 608 on your Reader Service Card add your name and address and drop it in the mail.

easier answers for . . .

STRESS WHEN CURVED SURFACES TOUCH

Because their contact area is small, stress is high. Here are two factors that simplify finding the stress.

ROBERT I ISAKOWER
Ordnance engineer
Picatinny Arsenal

Geometry tells us the contact area between two curved surfaces, or a flat and a curved surface, is zero—and therefore the pressure is infinite. Of course this isn't true in real life. Materials in nature are elastic and "give," forming a finite contact area. Divide contact area into load, and a resulting equation for compressive stress looks like this:

$$S_c = 0.918\sqrt{\frac{P\left(\frac{D_1 + D_2}{D_1 D_2}\right)^2}{\left[\frac{1-\mu^2}{E_1} + \frac{1-\mu^2}{E_2}\right]^2}}$$

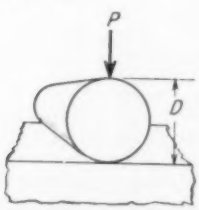
The simplified versions below lump the properties of the materials into one factor and most of the dimensions into the other. As a result, the long equation reduces to $S_c = K_2 G_2 \ (P/D^2)^{1/3}$.

Although an assumption behind the simplification is that the lengths of cylinders and all dimensions of plates are infinite, results are accurate unless a cylinder is very short, or a plate is less than five times the width of the contact area, or a plate is very thin.

Simplified equations

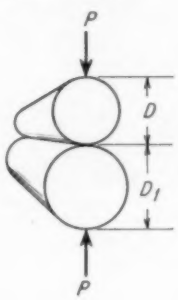
These equations give maximum compressive stress at the contact area S_c for six different cases. Cylinder on a flat plate

$S_c = K_1(P/D)^{1/2}$



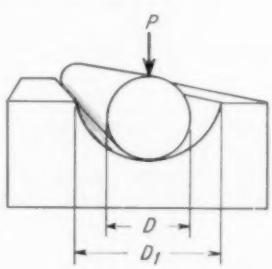
Cylinder on a cylinder

$S_c = K_1 G_1 (P/D^2)^{1/2}$



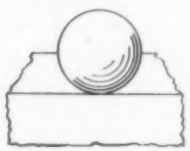
Cylinder in a cylindrical groove

$S_c = K_1 G_2 (P/D^2)^{1/2}$



Sphere on a flat plate

$S_c = K_2 (P/D^2)^{1/3}$



SYMBOLS

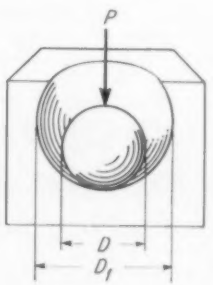
D	= Smaller dia of two touching curved surfaces, in.
D_1	= Larger dia of two touching curved surfaces, in.
$G_{1,2,3,4}$	= Dimensional factors
$K_{1,2}$	= Materials factors
P	= Total load, lb
S_c	= Compressive stress, psi

Sphere on a sphere

$S_c = K_2 G_2 (P/D^2)^{1/3}$

Sphere in a spherical socket

$S_c = K_2 G_4 (P/D^2)^{1/3}$



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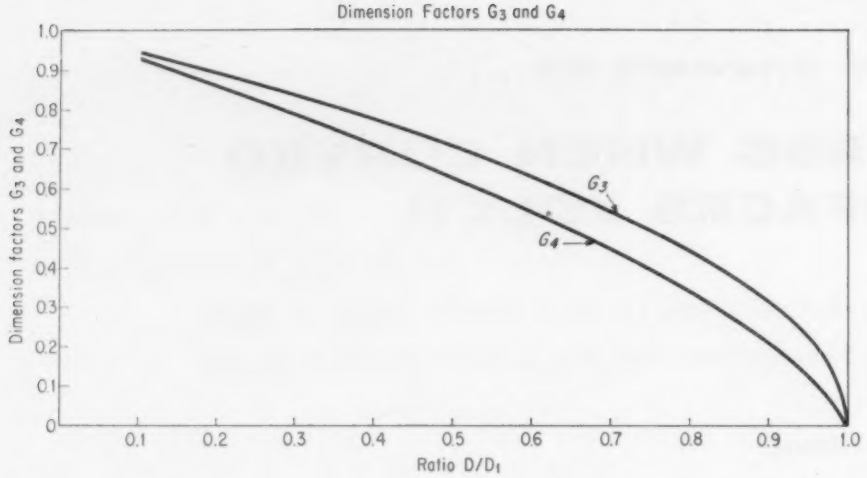

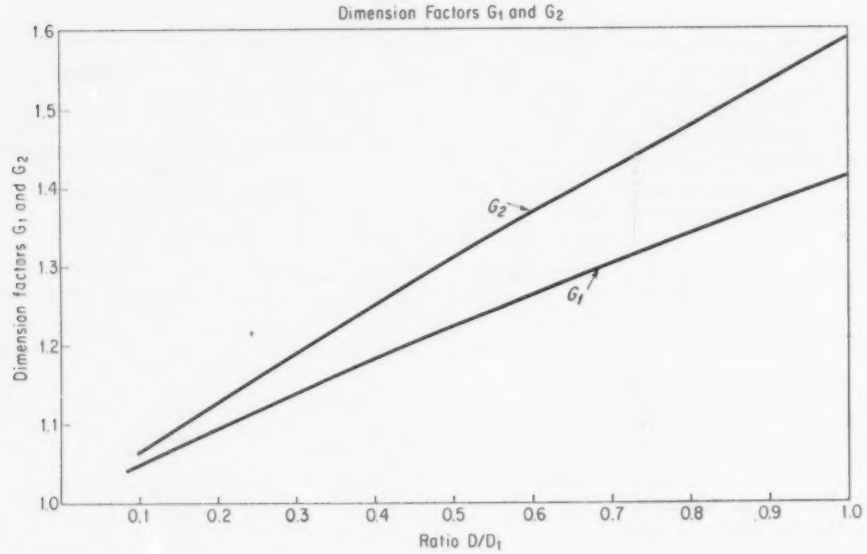

EXAMPLE: A 1-in.-dia aluminum ball rides in a 1.5-in.-dia copper socket, supporting a 230-lb load. What is the maximum compressive stress?

Solution: For a sphere in a spherical socket, compressive stress $S_c = K_2G_4(P/D^2)^{1/3}$. Find $K_2 = 33{,}000$ in the table under aluminum-copper. At $D/D_1 = 1/1.5 = 0.667$, pick $G_4 = 0.48$ of the curve. Putting these values into the equation,

$S_c = 33{,}000 \times 0.48(230/1)^{1/3} = 96{,}500$ psi

MATERIALS FACTORS K_1, K_2 FOR DIFFERENT METAL-TO-METAL COMBINATIONS

	Steel	Titanium	Copper	Brass	Grey Cast Iron	Aluminum
Steel	3195 58,500					
Titanium	2770 48,300	2485 41,700				
Copper	2700 46,600	2440 40,800	2390 39,400			
Brass	2665 45,900	2405 39,900	2360 39,100	2335 38,300		
Grey Cast Iron	2620 44,600	2375 39,200	2330 38,100	2301 37,600	2275 37,000	
Aluminum	2300 37,500	2130 34,000	2100 33,000	2080 32,800	2055 32,400	1890 28,700

Linde Coatings & materials News

LINDE COMPANY, DIVISION OF UNION CARBIDE CORPORATION

Surgical shears get longer life with LINDE tungsten carbide coating

Surgical shears with tungsten carbide coated on working surfaces now lose their cutting edge about *one-third* as fast as conventional shears. This has been proven under rigid testing supervised by a leading research laboratory.

The American Medical Instrument Corporation, Flushing, New York, uses the LINDE Flame-Plating process to improve the working surface and increase the wear-resistance properties of shears produced under its *Tuncarb* trade-mark.

The process has increased cutting life to the extent that *Tuncarb* shears in use for more than a year have not as yet been returned to AMICO for sharpening. By comparison, regular surgical shears used under the same conditions had to be returned as many as three times for restoration of working surfaces.

Coatings only .004″ thick

AMICO ships hot-drop-forged stainless steel parts to LINDE's new Flame-Plating plant at North Haven, Conn. Here, via the LINDE developed coating process, a .004″ thickness of tungsten carbide is actually "welded" to the precision wear surfaces of the instruments.

After coating, the blades and jaws are assembled, riveted, ground, polished, and buffed to a high finish by AMICO. The tungsten carbide surfaces themselves are finished with only a slight brushing. The same process is used to coat *Tuncarb* needle holders to provide tungsten jaws that give a firm grip on needles.

High-speed "blast-on"

The heart of LINDE's coating process is the LINDE Flame-Plating gun, into which exact quantities of oxygen, acetylene, and tungsten carbide or other powdered materials are fed by a special mechanism. After the gun is aimed at the area to be coated, controlled detonations "blast" the particles onto the work piece at speeds up to 2500 fps—until the desired coating thickness is reached.

Although temperatures of about 6000° F are attained within the detonation gun to heat powder to plastic state, the work piece itself is always kept below 400° F during the operation. There are no changes in the properties of the base metal and no distortion of the work piece regardless of its minuteness.

The inside cutting surface of the *Tuncarb* surgical shears shown here have been coated with tungsten carbide, reducing their rate of wear by as much as one-third.

In some uses, depending on the thickness of finish, the LINDE Flame-Plating process has been known to multiply wear resistance of metal parts by as much as 40 times.

For complete information on how you might use this advanced method of coating metals to improve production or reduce operating costs, check and send the coupon below.

LINDE synthetic sapphire solves guide problem in tape recorders

Second only to the diamond in hardness, LINDE synthetic sapphire provides unique wear-resisting characteristics. Because of its extremely low friction, hardness, and physical and chemical stability, several large manufacturers are using LINDE synthetic sapphire to solve the wear problem in tape guides on airborne and high-reliability tape decks, as well as in photographic film guides.

In these areas—where hardened steel guides show friction and wear almost immediately—sapphire wear is nearly imperceptible even after 100 hours of operation.

LINDE flame-polished synthetic sapphire is a convenient material for preventing edge-cutting typical with certain tapes in top and bottom guides.

For details on LINDE synthetic sapphire for any type of wear guide, instrument bearing, or other critical application, check and mail the coupon.

Chromium polished to maximum lustre with LINDE abrasives

In certain applications where it is necessary to achieve an extremely smooth surface on chromium finishes, such as in photographic rolls and processing rolls in the plastics industry, LINDE alumina abrasive powders of 99.98% purity have demonstrated unusual efficiency in removing the most minute protuberances.

Several leading photographic and precision parts manufacturers use LINDE abrasives, not only to obtain high-lustre finishes that protect materials, but also to refinish rolls several times over to avoid frequent replating.

Grades of LINDE alumina powders in sub-micron sizes are available for several cutting speeds or types of finish. For information, use the coupon below.

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270 Park Avenue
New York 17, N. Y.

Please send details on the items checked:

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- ☐ LINDE Alumina Abrasives

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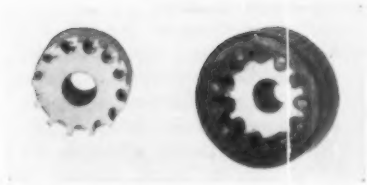
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Flexible coupling . . .
cushioned in urethane resistant to oil, absorbs angular and parallel misalignments as well as shock loads in any direction. Series of metal parts molded into rubber center member are proportioned to distribute load evenly. Said to last longer than metal counterparts and to have lower inertia factor resulting from urethane's light weight. Rubber member is stable from −80 to 275 F and is resistant to oxygen, ozone, oil and water. Outside of coupling is smooth rubber. Ten available models range in hp from 1/60 to 60 per 100 rpm and in max speeds from 25,000 to 3600 rpm. Priced from $14.50 to $275 each, with delivery in 2 to 3 wk. **Olson Industrial Products Inc, 40 W Water St, Wakefield, Mass.**

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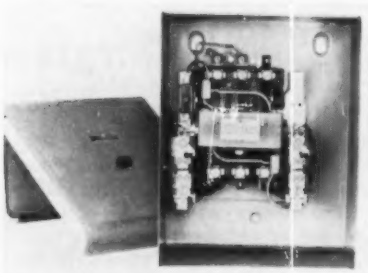

Contactors and starters . . .
are available in sizes 00 through 4, with addition of sizes 3 and 4 in open and enclosed forms, using horizontal, straight line magnet action. Size 3 devices are rated for control up to 50 hp, 600 v, size 4, up to 100 hp, 600 v. On Size 3 units, arc chute design consists of magnetic steel trap which exhausts ionized gases. Arcs are contained and quenched. On Size 4, arc is broken by metal grids embedded in arc-extinguishing compound. Bimetallic overload relays on both sizes are trip free. This is said to prevent contacts from being held closed during overload and damaging motor. Contacts are slanted, preventing dust accumulation and contamination. Size 3 enclosed forms have 3½-in. wiring space at top and bottom of enclosure; Size 4, 5 in. Former takes up to 1/0 wire, while latter takes up to 250 mcm cable. **General Electric Co, Schenectady 5, NY.**

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Underwater couplings . . .
are designed to run under water 24 hr per day for 3 yr without maintenance. Also operate in oil, mild chemicals and corrosives. Bodies are made of semi-steel castings, and outside collar and inside sleeves are hot-dipped galvanized. Set screws, lockwashers and retaining bolts are stainless steel, while cushions are made of Bakelite and boiled in water for 5 days to prevent swelling, shrinking or distortion after installation. Hp's range from 2.6 to 1365 at 100 rpm, bore sizes from solid to 9½ in. Contain no intricate mechanisms and can be installed in minutes, using only a straight edge. Metal jaws reportedly will not wear out because load is transmitted through cushions. Prices said to be comparable to standard couplings such as Types C and H, which range from $26.40 to $1080. Delivery within 15 days. **Lovejoy Flexible Coupling Co, 4856 W Lake St, Chicago 44.**

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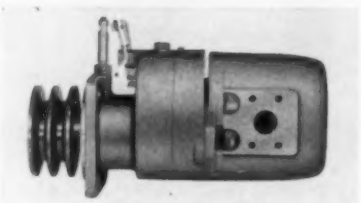

Clutch-hydraulic pump . . .
eliminating need for a power takeoff, is designed for equipment requiring compact means of engaging and disengaging a hydraulic circuit. Unit is for belt, gear or direct drive and provides engagement speeds (no load) from idle to 220 rpm. HP output ranges from ¼ to 30 hp and flow rate, from 1.7 to 26 gpm. Available in 9- and 19-lb gross weight series. Former has 4 models and latter, 3 models. All are for either clockwise or counter-clockwise rotation. **Berry Hydraulics, Div of Oliver Tyrone Corp, Corinth 1, Miss.**

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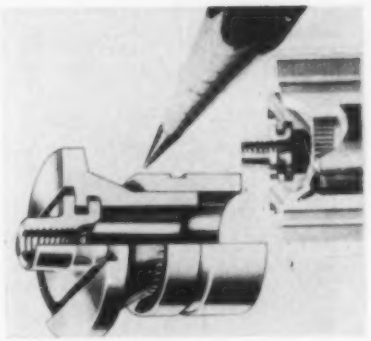


Structural floating locknut . . .
for honeycomb or sandwich type panels, combines a floating nut element with a structural type panel fastener. No intricate hole pattern and secondary riveting operation are needed to install fastener. One straight drilled hole prepares panel, and hand arbor press or any ram type equipment can be used to expand fastener within core area, enabling loads to be distributed to both cover sheets. Floating action is said to allow for total misalignment of 1/16 in. Available for ¼-in. and up panels, in sizes from 8-32 to ¼-28. Body section can be supplied in aluminum, carbon or stainless steel. **Delron Co Inc, 5224 Southern Ave, South Gate, Calif.**

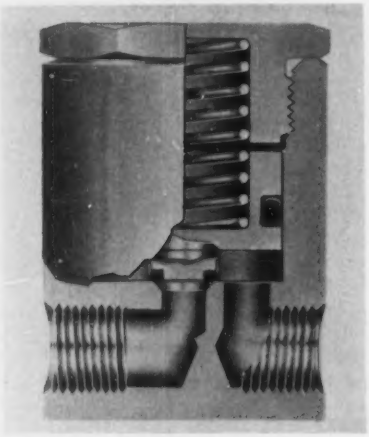
Circle 304 on Reader Service Card

Flame-retardant laminate . . .
is glass-base, epoxy-resin laminated sheet (Fireban 600) which can be supplied with copper cladding (Fireban 600 E) for making printed circuits. Fireban 600 sheets are approx 37 x 49 in. and are available with thicknesses from 0.010 to 2 in. Sheets up to 1/16-in. thick can be cold punched. Properties of 1/16-, ⅛- and ¼-in. thick sheet stock include: max operating temp of 300 F continuous and 325 F intermittent; flexural strength of 85,000, 80,000 and 70,000 psi lengthwise, condition A (65,000, 60,000 and 55,000 psi crosswise, condition A); and tensile strength of 75,000, 70,000 and 65,000 psi lengthwise, condition A (70,000, 58,000 and 55,000 psi crosswise, condition A). Fireban 600 E is furnished in 36 x 48-in. sheets with electrolytically deposited copper foil on one or both sides. Foil has min purity of 99.5% and is available in thicknesses of 0.0014, 0.0028, 0.0042 and

continued on page 70

0.0070 in. Differential adhesive layer is not required under copper since epoxy resin in base stock is said to have excellent adhesive properties. Bond strength, condition A, for composite sheets is 8 lb for 1-oz cladding; 10 lb for 2-oz cladding; 12 lb for 3-oz cladding; and 14 lb for 5-oz cladding. **Taylor Fibre Co, Norristown, Penna.**

Circle 305 on Reader Service Card



Priority relief valve . . .

operating at pressures to 2000 psi, is actuated by absolute system pressure rather than differential pressure between inlet and outlet. Fail safe valve closure is effected by positive spring pressure whenever downstream pressure drops below design closing pressure. Valve permits absolute leakproof isolation of upstream portion of a system at pressures below preset point to prevent withdrawal of pressures to auxiliary systems beyond a point that would jeopardize proper functioning or safety of primary system. Above preset pressure, valve is full open, permitting flow to downstream system with virtually zero drop. Has ¼-in. female pipe connections. **Circle Seal Products Co Inc, 2181 E Foothill Blvd, Pasadena, Calif.**

Circle 306 on Reader Service Card

Subminiature indicator light . . .

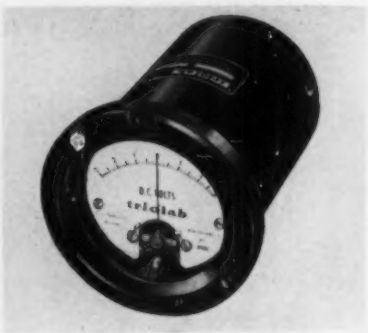
is watertight on face of panel, achieved by means of two $\frac{1}{16}$-in. thick Neoprene-retained O-ring seals. One O-ring is retained within back of lens; other within flange of mounting bushing. Measures $1\frac{5}{16}$ in. in over-all length and mounts in a single $\frac{15}{32}$-in. clearance hole. Lens cap is prevented from rotating by terminal location washer whose eccentric shape enables it to be tightly engaged and locked by flared-over edges of notched bushing. Fully-insulated unit accommodates midget flanged base incandescent lamps with voltages from 1.3 to 28 v. Plastic stovepipe-shape lens is available in 6 translucent or 7 transparent colors. **Dialight Corp, 60 Stewart Ave, Brooklyn 37, NY.**

Circle 307 on Reader Service Card

One-part epoxy dip coat . . .

is said to provide a strongly adhesive surface coat with excellent moisture resistance on transformers, capacitors and similar components. Applied by conventional dip coating procedures. Preheated parts are dipped into resin, which gels on part's surface and reportedly will not run or drip during oven cure cycle. Amount of pickup is controlled by preheat temp and immersion time. During cure, there is no evolution of volatile materials. Controlled amount of flexibility in cured resin is said to give outstanding resistance to thermal and mechanical shock. Measures 8 lb per gal. and priced at $6 for 2-lb kit; $1.45 per lb for 1 gal. can; $1.35 per lb for 5-gal. pail; and $1.30 per lb for 55-gal drum. **Emerson & Cuming Inc, Canton, Mass.**

Circle 308 on Reader Service Card



All-transistor dc voltmeter . . .

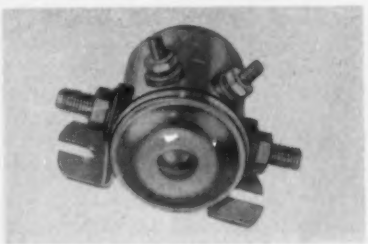
is self-contained instrument that requires only 3½ in. panel space and weighs less than 1½ lb. Eliminates zero drift and necessity for zero controls. Amplifier section uses five transistors and is chopper-stabilized. This allows for a selection of ranges from as low as 100 mv on each side of zero, while maintaining a constant high input impedance of 1 megohm min. Standard range of one model is 0.5-0-0.5 through 300-0-300 v dc (zero center); range of second model, 0-1 through 0-300 v dc (zero left). Accuracy is 2% of full scale. Installation and maintenance is made simple by unit's built-in power supplies with only two 400-cps power leads, two signal leads and one case lead to connect. Requires only one electrical adjustment and can be calibrated in field without being removed from position on panel. **Trio Laboratories Inc, Plainview, LI, NY.**

Circle 309 on Reader Service Card

Liquid-level control . . .

is single sensor ultrasonic unit which is unaffected by foam, liquid viscosity, specific gravity or vibration. Operates equally well in conductive or nonconductive liquids and slurries. Has on-off electrical ratio of 30:1 with adjustable sensitivity to provide repeat accuracy to 0.005 in. Available for use from −425 to 450 F. System consists of transistor-equipped amplifier, power supply and output relay, all enclosed in a metal control box; and a sensing unit which is hermetically sealed in 304 stainless steel and furnished with up to 100 ft of cable. Safety factor in liquids under pressure is 2000 psi with 4:1 min burst. **Aro Equipment Corp, Industrial Div, Bryan, Ohio.**

Circle 310 on Reader Service Card



Silver-contact solenoid switch . . .

rated 100-amp load, 500,000 cycles, is for engines and motors using standard 12-v current. Closes and seals at 60% of rated voltage in any position at normal room temp. Release voltage is said to be 15% of rated voltage. Passes 700-v ac breakdown test between case and current carrying parts indefinitely. Includes double terminal insulated coil; standard $\frac{5}{16}$-24 studs; 10-32 coil terminals; automotive type mounting bracket; and 50% duty cycle (10 min. on-10 min. off max). **Clum Mfg Co, Milwaukee.**

Circle 311 on Reader Service Card

Miniature shuttle valve . . .

only ¾ in. over-all, is designed for multiple fluid power circuitry of cylinders, controls and safety devices. Sliding piston with Buna-N seals alternates flow from two inputs to a single output, but never to other input. Exhaust is through input port where pressure was last applied. Any number of units can be joined together

continued on page 73

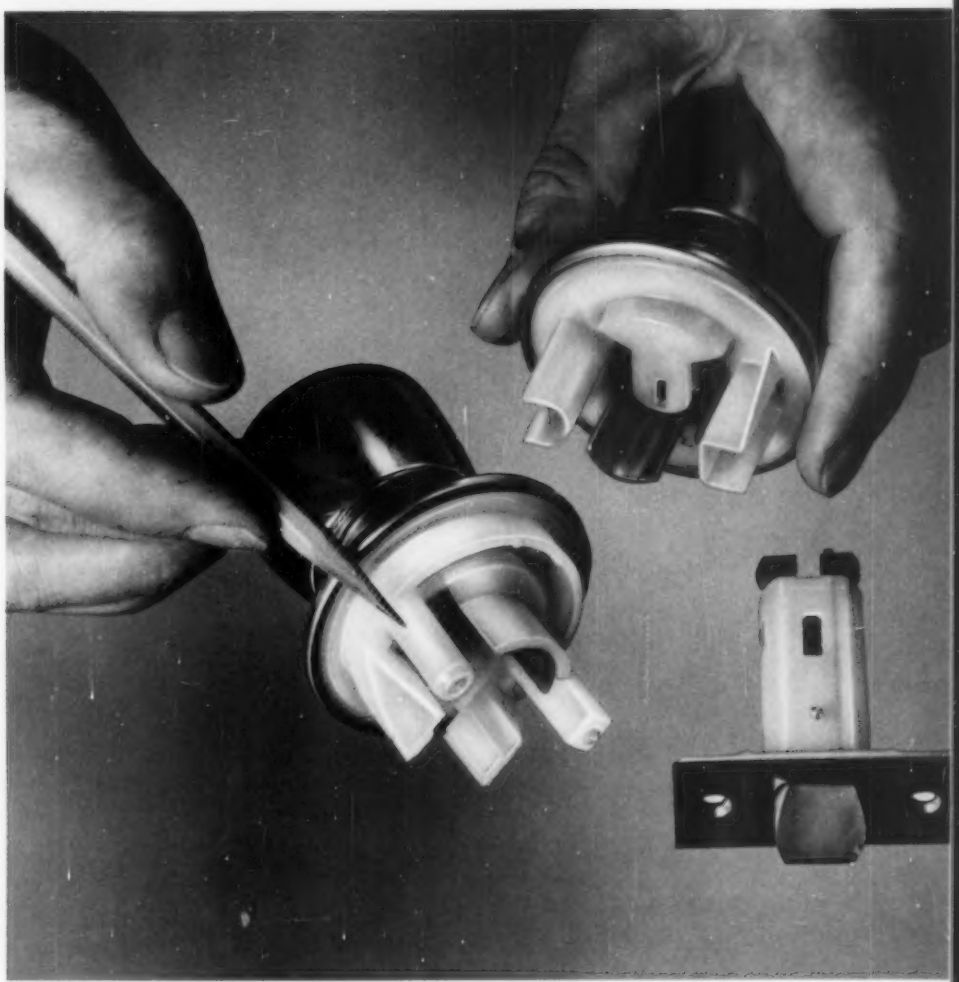
CIRCLE 71 ON READER SERVICE CARD→

working with

Du Pont Zytel®

NYLON RESIN

one of Du Pont's versatile engineering materials



New lockset designed with ZYTEL® NYLON RESIN offers easy installation...lifetime service...economical production

This lockset looks better, lasts longer than the metal one it replaces—and it took a material with remarkable properties to make it. It took a material that is exceptionally tough and abrasion-resistant, a material with friction so low as to make lubrication unnecessary, a material that is rust- and corrosion-proof, a material that can be economically molded to close tolerances in large quantities, and one that requires little or no finishing.

In short, it took Du Pont ZYTEL nylon resin.

In this radical design innovation, almost all working parts except the knobs are molded of tough Du Pont ZYTEL. Installation of the lockset is made foolproof; round and square sleeves mate with round and square posts. The entire set is held by two double lead bolts that drive directly into holes in the chassis sleeves. And a self-aligning latch case lets the installer swivel the latch to the right or left of the central lock assembly for bevel-edged doors or for improper boring. In action, the bolts of ZYTEL were tested up to 1,500,000 cycles—equivalent to more than 100 years of normal household use—without perceptible wear. And the lockset functions smoothly and quietly without lubrication. Molded by Nylon Products Corp., affiliated with F. J. Kirk Molding Co., Clinton, Mass., for Lockwood Hardware Manufacturing Co., of Fitchburg, Mass., the parts are economically mass-produced, need virtually no finishing operations.

On the following page, you will find further illustrations of the design improvements and cost reductions made possible by the complete line of ZYTEL nylon resins.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING

...THROUGH CHEMISTRY

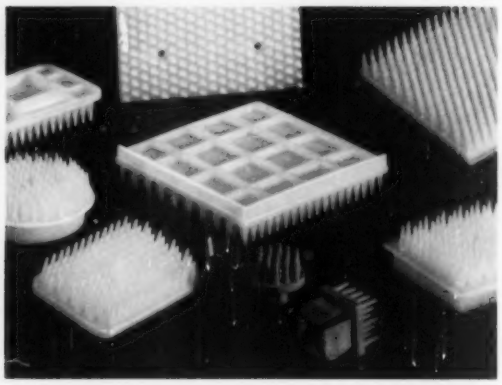
working with

Du Pont Zytel®

nylon resins

one of Du Pont's versatile engineering materials

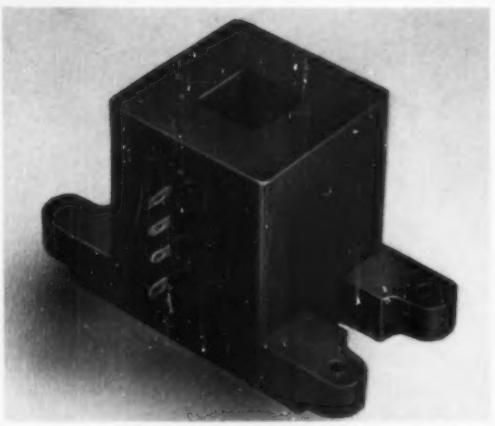
When installed in a teletypewriter, these wheels will be subjected to steady abrasion on the typewriter ribbon. The wheels are molded of ZYTEL, because of its impact and abrasion resistance, as well as its moldability and the exacting tolerances which can be held. (Molded by General Die Mold, Chicago, Illinois, for Kleinschmidt Division of Smith-Corona Marchant, Inc., Deerfield, Illinois.)



Heavy loads are supported by small carpet protectors made of ZYTEL. Support is distributed by the many tiny nylon "icicles" that reach the floor between the tufts of rug—instead of crushing the rug under the object's weight. Factors in the choice of ZYTEL were strength and resistance to creep or cold flow. (By United States Caster Cup Corporation, Kansas City, Mo.)

Parts of ZYTEL® NYLON RESIN resist abrasion, stand up to impact, mold easily

A large part of the ZYTEL success story is attributable to its versatility of application. In complete operating units or in working parts, its remarkable array of properties—mechanical, chemical, electrical and processing—makes it a natural problem solver in design. Your own design may well benefit from the contribution of a particular composition of ZYTEL. To learn more about the performance of the different compositions of Du Pont ZYTEL, just complete and mail the coupon below.



Coils encapsulated in ZYTEL offer high dieletric strength with relatively thin coatings. Coils are protected against humidity, acids, alkalies, and oils. The coatings can also be used as bearing surfaces, as in solenoids and contactors, thanks to the abrasion resistance and low friction of ZYTEL nylon resin. The mounting feet shown are molded as an integral part of the encapsulation. (Processed by Anderson Controls, Franklin Park, Illinois.)

POLYCHEMICALS DEPARTMENT

DU PONT

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BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.), Dept. 2
Room 2507Z, Nemours Building, Wilmington 98, Delaware.

Please send me more information on Du Pont ZYTEL. I am interested in evaluating this material for: A B C

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Street Address_____

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Type of Business_____

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec

ZYTEL® *nylon resins*

Alathon® · Delrin® · Lucite®

to actuate one cylinder, with valves controlled by solenoids, cam followers or manual pushbuttons from one or different pressure sources. Recommended working range is 0.5 to 250 psi. Air flow rate is 5 cfm at 50 psi. Made of brass, with input ports tapped for 10-32 fittings. **Clippard Instrument Laboratory Inc, 7390 Colerain Rd, Cincinnati 39.**

Circle 312 on Reader Service Card

Wirewound potentiometer . . . dissipates 15 w at 77 F with a max operating temp of 509 F. Has multi-wire resistance element termination, which results in metal-to-metal bond able to withstand thermal stress of high temp operation. Resistances are 10 to 10 k ohm; nominal resolution, down to 0.60%; size, 1.07 x 0.52 x 1.27 in.; and weight, 0.9 oz. Priced at approx $8 to $10 in production quantities. **Bourns Inc, 6135 Magnolia Ave, Riverside, Calif.**

Circle 313 on Reader Service Card

Microminiature potentiometer designed for potting, has open construction so that potting compound can penetrate it to fix wiper in any preadjusted position and make unit immune to shock, vibration, humidity and tampering. Available in stud- and lead-mounted, wirewound models with resistance values from 100 ohm to 10 k. End resistance is less than 1%; resolution, 0.25 to 1%, depending upon resistance value; and power rating, 0.25 w. Both models have ¼-in. dia and ¾-in. body length; weigh 0.02 oz. **Miniature Electronic Components Corp (Minelco), Holbrook, Mass.**

Circle 314 on Reader Service Card

Miniature shutoff valve . . . with positive bonnet lock, is suitable for use with oxygen, nitrogen, helium, air, fuels, hydraulic oils and chemicals. Typical applications include gas sampling cylinders, pressure gages, high pressure instrument sampling lines, etc. Operating temp is from —65 to 250 F for hi-vacuum to 3500-psi service, with shutoff torque

continued on page 75

SPECIFY WOOD'S ULTRA-V DRIVES

Wood's Ultra-V Drives offer tremendous savings over conventional v-belt drives . . . up to 50% in space, 27% in weight, 30% and more in costs. And there are savings on bearings, bases and housings. Greatly improved belt materials and belt construction assure unmatched dimensional stability, amazing strength, greater grip, added support and equalized load for tension members. High performance, Ultra-V sheaves have smaller diameters, less width, less weight and tremendous strength, are equipped with famous "Sure-Grip" Bushings.

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CIRCLE 73 ON READER SERVICE CARD 73

Wider Range of Gas Heat Control now available from Robertshaw

Equipment designers now have a wider temperature range . . . from 150° to 700°F . . . in which to design and operate gas-fired equipment and appliances . . . with full control at any point in the temperature range.

The perfection of a combination snap and throttle thermostat, Robertshaw's **FLAME MASTER FD** gives flat-line control from 300° up . . . and very modest fluctuations in the low range, with full control down to 150°. Even the *minimum* flame setting is under thermostatic control.

With Robertshaw's **FLAME MASTER FD** also comes wide adaptability of installation through design flexibility to meet your product's physical requirements.

Robertshaw engineers will be glad to review the temperature control requirements of your new product design in the strictest confidence.

FLAME MASTER FD could well be the temperature control you need. Write Robertshaw Thermostat Division, Robertshaw-Fulton Controls Company, Youngwood, Pennsylvania. For real fast service, use DIRECT DISTANCE DIALING. Dial 412-242-7171.

Robertshaw

. . . the name that MEANS temperature control

VMA 8023

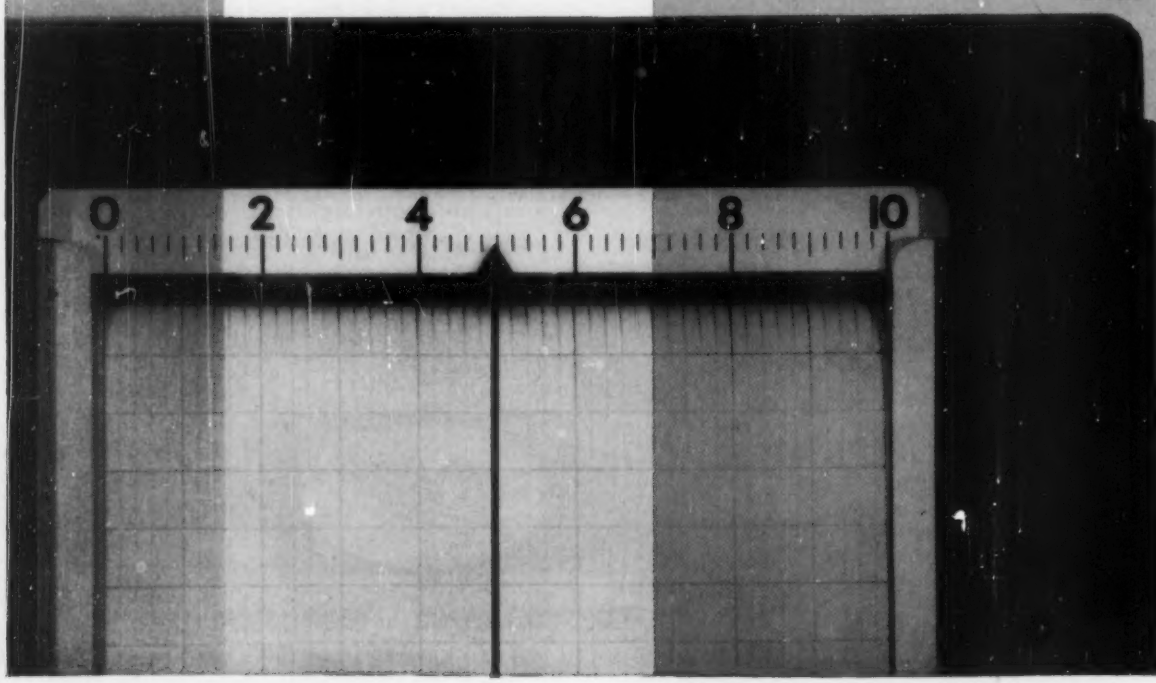
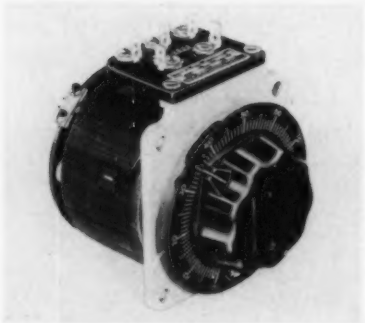


Photo of Speedo-Max Recorder courtesy Leeds & Northrup Company

of 6 in.-lb at 2000 psi. Measures ¾ in. wide, 1⅞ in. long and approx 2 in. high in open position. Two ¼-in. male pipe ports are provided. Made of stainless steel and weighs less than 5 oz. **Robbins Aviation Inc, 2350 E 38th St, Los Angeles 58.**

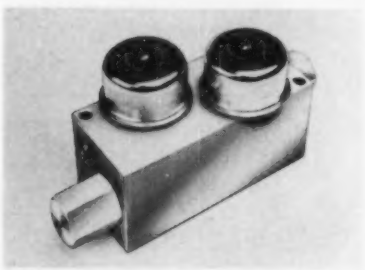
Circle 315 on Reader Service Card



Variable transformers . . .

have output ratings up to 3.75 amp with constant current loads and up to 5.5 amp with constant impedance loads. Rated for 50/60 c, single- or three-phase duty. Each includes adjustable, solid metal ⅜-in. shaft; gold alloy plated commutator; functionally designed terminal arrangement for flexibility in type of connections; terminal adapters for either soldered or push-on connectors, etc. Square base design is said to increase strength and reduce overall height and space behind panel. Available are manually-operated and motor-driven single-, two- and three-gang types. **Superior Electric Co, Dept 21, Bristol, Conn.**

Circle 316 on Reader Service Card



Double flow regulator . . .

is pressure-compensated unit incorporating two combination bypass and restrictive-type flow regulators in series. Has 12 position detents, dustproof dial adjustments and bottom-located ports. Latter includes an inlet, two O- to 15-gpm regulated ports and a bypass port. Inlet and bypass ports are ¾-in. pipe and both regulated ports are ½-in pipe. Flow from bypass port can be independently used for system functions. Unit can be installed in fluid power systems handling pressures of up to 3000 psi. Permits manual adjustment of hydraulic fluids to two separate functions. **Fluid Controls Inc, Box 186, Mentor, Ohio.**

Circle 317 on Reader Service Card

Inert gas-filled thyratron . . .

is a quick-starting 3.2-amp dc tube designed for welding control, motor control and other industrial uses. Other ratings include: filament volts, 2.5; filament amps, 11.5; and peak anode current, 40. Operates within ambient temp limits of –67 to 167 F. Weighs 8 oz. **National Electronics Inc, Geneva, Ill.**

Circle 318 on Reader Service Card

Time-delay relay . . .

consists of a solid state time delay network which drives a slave relay. Uses a commercial relay, germanium semiconductors and is designed for uses where shock and vibration requirements are not critical. Time delay can be varied within standard range of 25 to 500 millisec (longer delays available on request). Timing accuracy is ±10% at fixed voltage. Supplied in 12- and 28-v dc versions (ac inputs also available). **Guardian Electric Mfg Co of California Inc, 5575 Camille Ave, Culver City, Calif.**

Circle 319 on Reader Service Card

Small temperature controller

is resistance bulb signaling type that handles range from –150 to 1050 F. Said to be smallest and lowest cost unit with 22-in. scale. Since each unit requires less than 5 x 8-in. panel space, three will fit in a standard 9 x 19-in. rack panel. Interchangeable scales are printed on stainless steel in 1° graduations and 300° spans for both F and C. Only one probe handles all ranges. Includes transistor-equipped circuitry, platinum resistance thermometer sensing element, and plug-in construction. **Technique Associates, 1413 N Cornell, Indianapolis 2.**

Circle 320 on Reader Service Card

Dc meters . . .

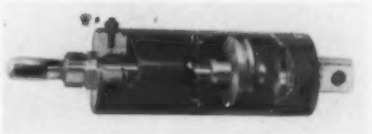
have full open dials behind clear plastic fronts, said to give longer, more readable scales than other meters of same sizes. Four sizes range in scale length from 2.5 to 7 in. Have 3-way terminals which permit use of push-on solderless connectors; conventional solder terminals; or conventional wrap-around (binding head screws). **Triplett Electrical Instrument Co, Bluffton, Ohio.**

Circle 321 on Reader Service Card

Thin-wall seamless tubing . . .

is redrawn to walls of 0.0005 in. with tolerances as close as ±0.00005 in. Supplied in any specified dia size from 0.010 to 0.375 in. OD and in 304, 310, 316, 321 and 347 stainless steel. Can be cut to exact lengths with ends concentric and burr-free. Said to be extremely lightweight. Ten miles of 0.375-in.-OD tubing x 0.0005-in. wall reportedly weigh less than a pound. **Uniform Tubes Inc, Collegeville, Penna.**

Circle 322 on Reader Service Card



200-psi cylinders . . .

from stock in 1½-, 2-, 3- and 4-in. bore sizes, permit installation of inexpensive adjustable cushion kits (only $1.50 to $2 max) at any time without disassembling unit. Also have chrome-plated steel piston rods with wrench flats, and metallic rod wipers with automatic wear compensation. Another stock size, 1⅛-in. bore, comes with stainless steel rods and fixed cushions. **Modernair Corp, 400 Preda St, San Leandro, Calif.**

Circle 323 on Reader Service Card

Size-11 ac motors . . .

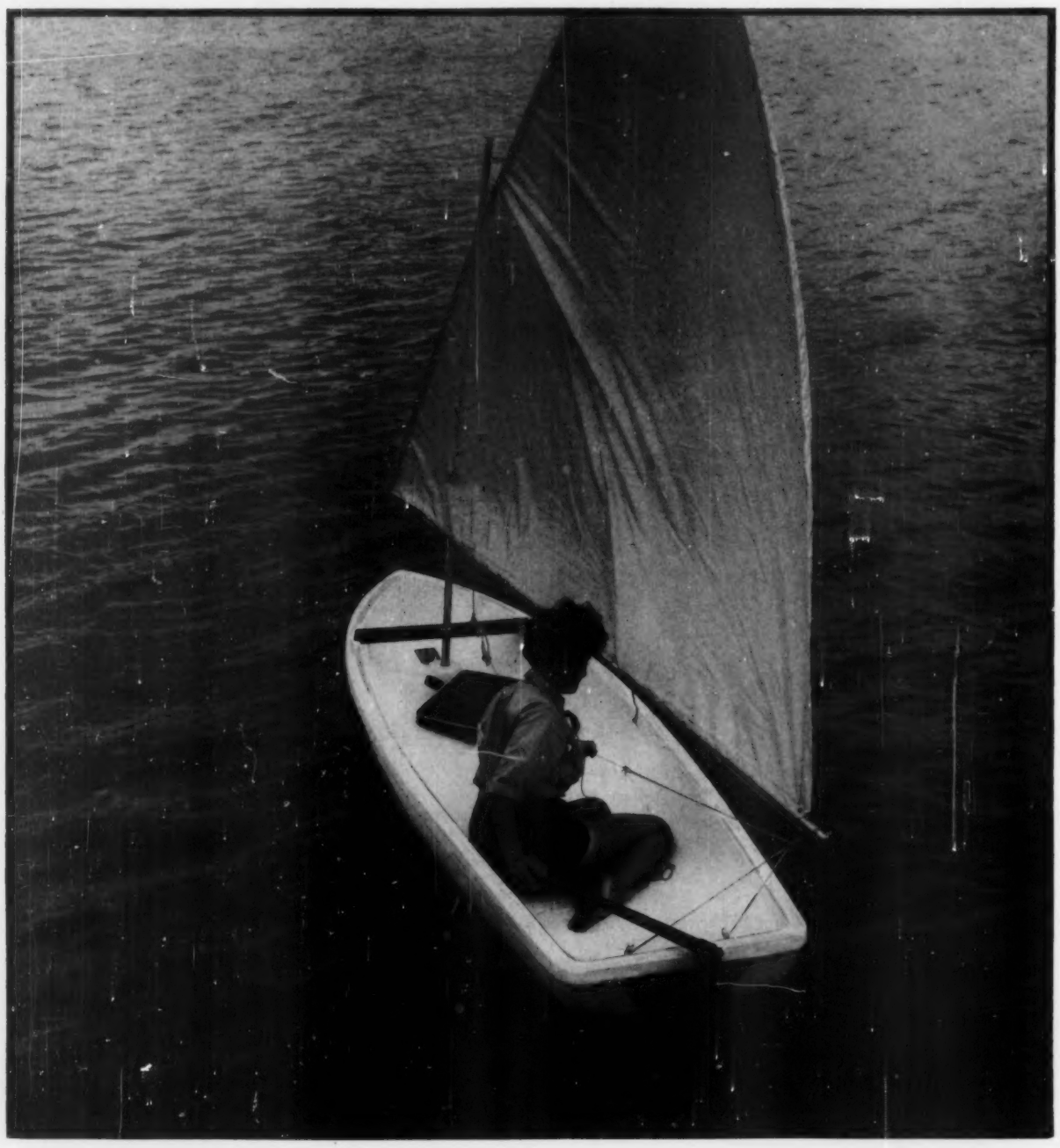
with fractional-hp ratings, include: low slip induction; torque; single, dual and 3-speed hysteresis units. Operation is on

continued on page 79

PLASTIC DESIGN IDEAS THAT MAY GIVE YOU AN IDEA

Foam plastic makes this boat unsinkable

The hull of this 11 ft. sailboat, designed to sell for under $100, is one solid piece of foam plastic—DYLITE® expandable polystyrene. Because of its tight cell structure and light weight, this amazing material has unmatched buoyancy. The boat stays afloat even if it's completely flooded. It can't become waterlogged because DYLITE doesn't absorb water. The hull weighs only 30 pounds, yet it can support over 500 pounds. Another Koppers plastic, DURETHENE® polyethylene film, is used in the durable yellow sail. Boat manufactured by Snark Products, Inc., Fort Lee, New Jersey.



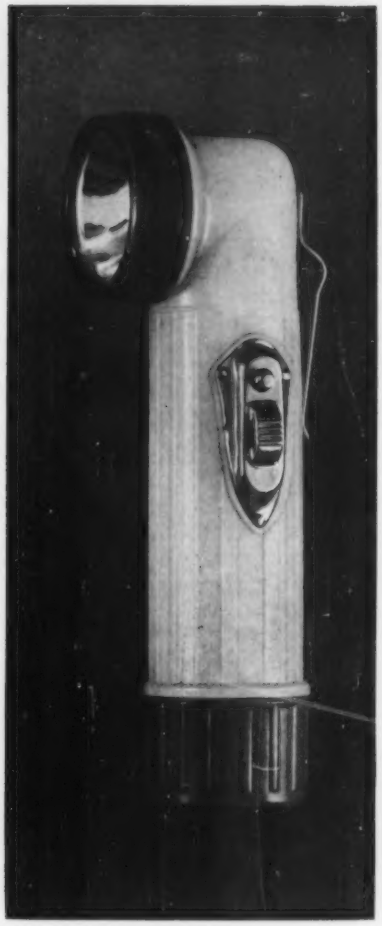
Cooler liner formed without thin spots

The interior liner of this Hamilton-Skotch picnic chest is thermo-formed from SUPER DYLAN® high-density polyethylene. This impact-resistant plastic is used because it's the only polyethylene that can be formed into this difficult deep-draw piece without producing thin spots or mold marks. The seamless liner won't leak, absorb food odors or water. Its smooth, white finish can't stain, discolor, rust or corrode—it's easy to keep clean. Bottles, cans and chunks of ice won't mar or crack its tough surface. Cooler Chest Manufactured by The Hamilton-Skotch Corporation, New York 16, New York.

Foam trays simplify toy packaging

A. C. Gilbert Company uses DYLITE expandable polystyrene trays because they completely eliminate costly interior packing materials. DYLITE trays are strong, good looking, easy to assemble and load—they save on labor costs. They also cut shipping costs because they're extremely lightweight.

DYLITE packages come in any size or shape; they fit firmly around the product and protect it from shipping damage. They make an attractive display because their smooth, colorful surface won't smear, chip or flake. DYLITE parts molded by Sullifoam Products, Willow Grove, Pennsylvania.



Flashlight guaranteed not to break

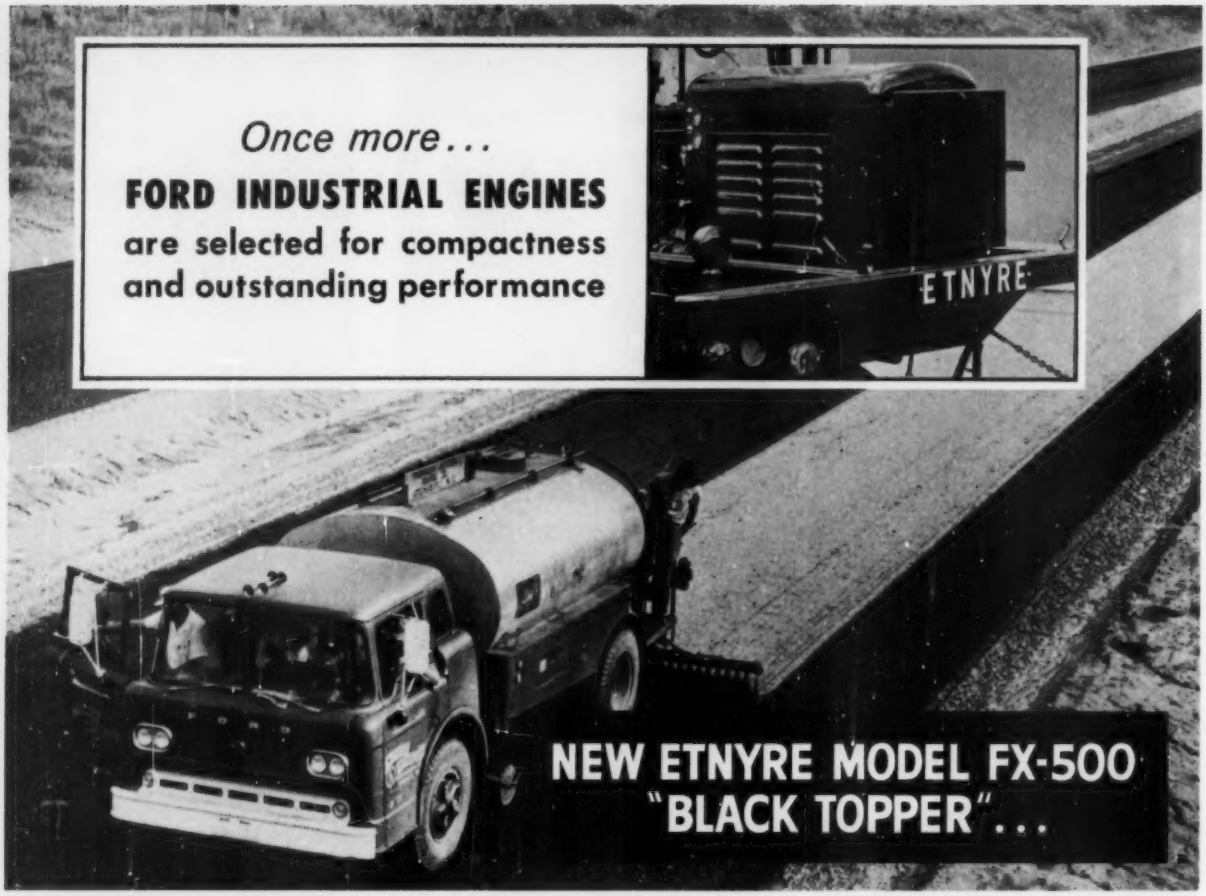
This new right-angle flashlight case is guaranteed unbreakable because it's molded from strong DYLAN® polyethylene. It's colorful, can't chip or flake. Unlike metal flashlights, it won't rust or corrode and it's completely acid-proof.

Koppers has a wide range of polyethylenes available for almost any application. They come in densities from .914 to .953 gm./ml. By varying density, molders or design engineers can get varying degrees of stiffness, heat distortion and tensile strength. Remember too, that polyethylenes can give you a wide range of colors. Flashlight manufactured by J. P. Gits Corp., Chicago, Illinois.

KOPPERS PLASTICS

Find out how Koppers family of plastics can help improve your product at less cost. For more details write Koppers Company, Inc., Plastics Division, Dept. 1530, Pittsburgh 19, Pa.

KOPPERS®



designed for maximum payloads... and dependable, economical operation!

It's easy to see why Etnyre chose a Ford Industrial Engine for their FX-500 "Black Topper" . . . Ford engines deliver the kind of peak performance that construction work requires. Dependability and economy of operation are just *two* of the many advantages enjoyed by OEM's using Ford Industrial Engines. They're *compact* engines, allowing greater freedom of equipment design, and delivering *more horsepower per pound of engine weight than ever before possible!*

Parts and service availability is *immediate*, with a nationwide network of Ford Dealers carrying a complete stock of more commonly purchased engine parts.

Only Ford offers a full line of modern, overhead-valve design engines to meet every power requirement.

YOUR JOB IS WELL-POWERED WHEN IT'S FORD-POWERED!

Ford engines range from 134 to 534 cubic inches, including modern diesels. Most of these engines are available as foot- or skid-mounted power units. Whatever your industrial power need, it'll pay you to specify Ford Industrial Engines.

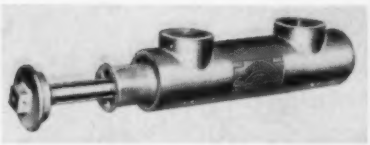
Ford
INDUSTRIAL ENGINES
AND POWER UNITS

INDUSTRIAL ENGINE DEPARTMENT, FORD DIVISION, FORD MOTOR CO., P.O. BOX 598, DEARBORN, MICH.

West of Rockies write to:
FORD INDUSTRIAL ENGINE DEPT., P.O. BOX 6787, LOS ANGELES 22, CALIF.
FORD INDUSTRIAL ENGINE DEPT., P.O. BOX 1666, RICHMOND, CALIF.

60 or 400 c, single, 2 or 3 phase, 115 v or 120/208 v. Hp's range from 1/150 at 900 rpm to ¼ at 3300 rpm, depending on application. Dimensions range from 3 1/8 to 6 1/8 in. long, with diameter constant at 4 3/8 in. Weights range from 4 lb for smallest of 14 models to 18 lb for largest size. Motor housings are aluminum, cast around laminations, and die-cast end-bells are rabbeted to frame. **Ashland Electric Products Inc, Dept PRE, 35-02 Queens Blvd, Long Island City 1, NY.**

Circle 324 on Reader Service Card



Ferrous trap and filter . . .

combined into one compact unit, removes both iron contamination and nonmagnetic particles. Heart of unit is a 1-in. stainless steel, permanent tube magnet enclosed in a 2-in.-dia perforated bronze filter screen with either 0.020- or 0.033-in.-dia holes. Magnet and filter are enclosed in a 350-lb pressure bronze casting with standard 2-in. pipe thread inlet and outlet. Material is passed over magnet first and then through filter, or vice versa. **Eriez Mfg Co, Erie, Penna.**

Circle 325 on Reader Service Card

Idler pulleys . . .

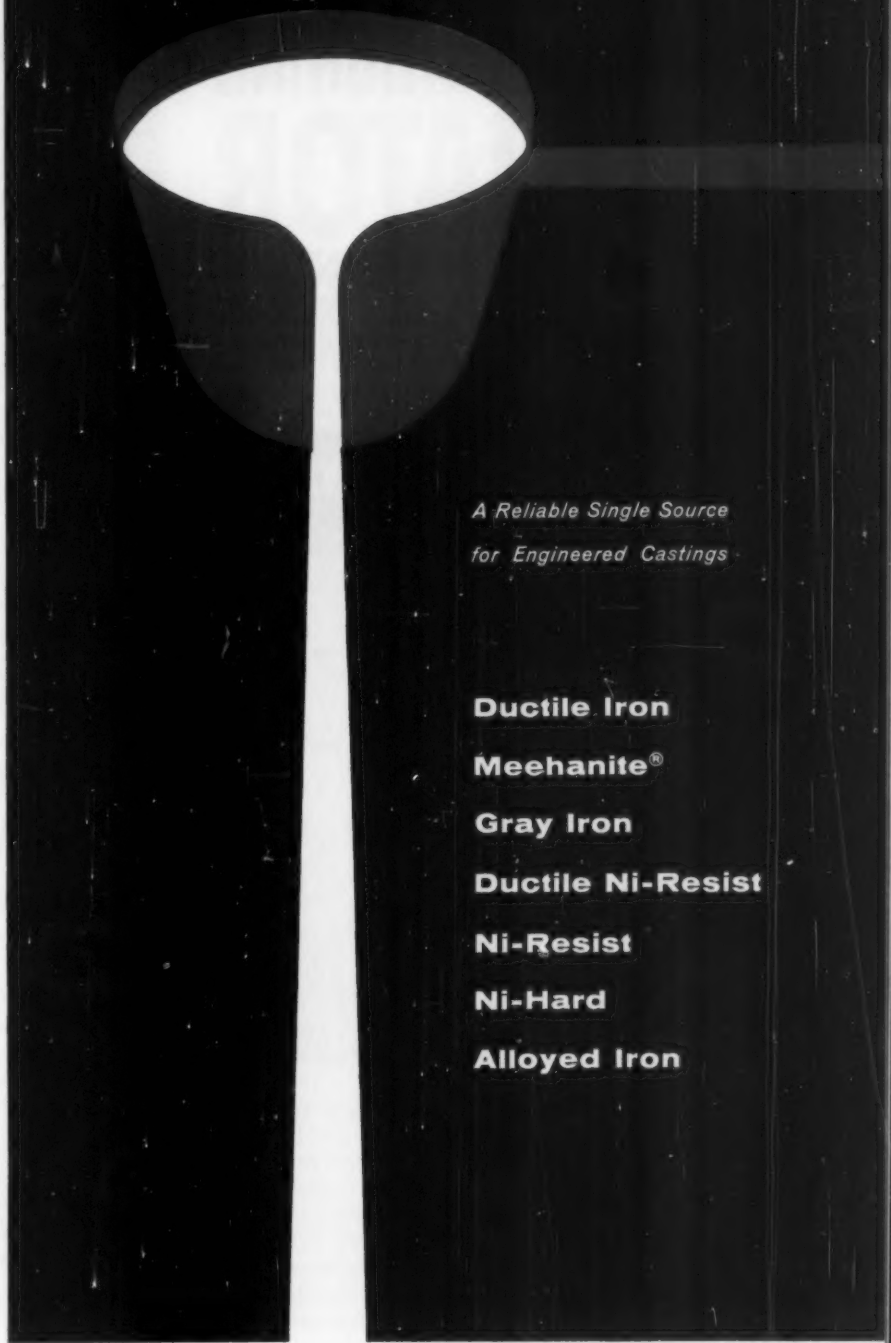
contain full complement, double-row ball-bearings with hardened, deep groove races, which give units max load-carrying capacity and extended life. Symmetrical sheave halves (sheaves made in a variety of types to suit flat or V-belts) are spot-welded together around bearings. Supplied with an extended inner race on one side to give mounting clearance and eliminate spacers. Bearing bores fit standard machine bolt sizes. Prelubricated and completely sealed. Priced at approximately that of conventional double-sealed, single-row bearings. **New Hampshire Industries Inc, Hanover, NH.**

Circle 326 on Reader Service Card

Seamless stainless steel tubing . . .

is from stock, starting this month, in ¼- through 6⅜-in. ODs with wall thicknesses up to ⅞ in. Stainless types will initially consist of Types 304, 316 and 347. Pipe, also from stock, include ⅛ through 6 in. in Schedules 5, 10, 40, 80, 120, 160 and

continued on page 81



HAMILTON FOUNDRY INC.

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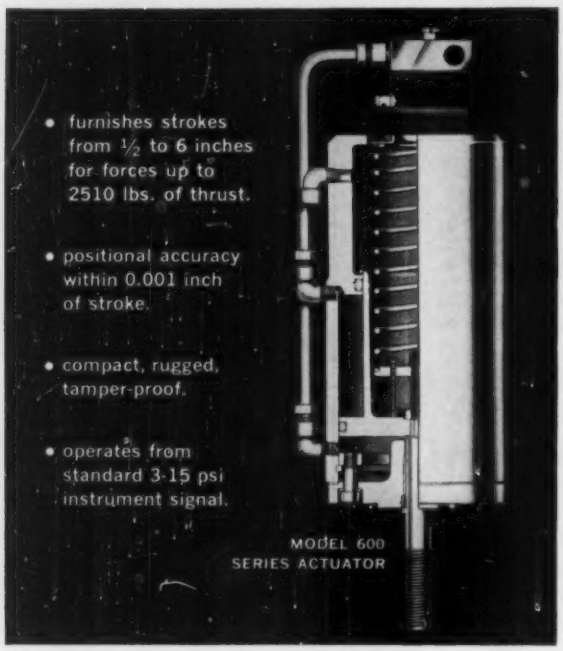
STROKE POSITIONING ACTUATOR

FOR THE PRECISE CONTROL OF YOUR VARIABLE SPEED DRIVES • CONTROL VALVES • RHEOSTATS & PUMPS!


• furnishes strokes from ½ to 6 inches for forces up to 2510 lbs. of thrust.
• positional accuracy within 0.001 inch of stroke.
• compact, rugged, tamper-proof.
• operates from standard 3-15 psi instrument signal.
MODEL 600 SERIES ACTUATOR

Adaptability, speed, precise positioning and *power* are features of Annin's 600 Series actuators, designed for easy mounting on your existing equipment. Compact and rugged, these units may be operated from a standard 3-15 psi instrument signal, with a positional accuracy within 0.001 inch per inch of stroke. Supply pressures as high as 100 psig of air or gas can be used as the actuating medium. The compact, tamper-proof construction practically eliminates maintenance. Given a clean dry supply medium, long periods of trouble-free operation can be expected.

SEND FOR COMPLETE DETAILS
Ask for Actuator Bulletin 1236 s.t. containing complete technical information on Series 600 and other Annin actuators.

THE ANNIN COMPANY

DEPT. P-E • 1040 South Vail Avenue • Montebello, Calif.

Latest Advance in SPRING DESIGN

NEW SANDVIK Integral Band Springs*

Sandvik's newest development in spring design is a self-contained unit accomplished by mechanically joining together the two outer convolutions of the spring.

Give You These Advantages

- CAN BE SAFELY INSTALLED OR REPLACED IN SECONDS
- HOLDER OR KEEPER NOT REQUIRED
- MAY ELIMINATE THE NEED FOR BARREL OR HOUSING
- MINIMIZES NORMAL FRICTION
- PROVIDES MORE UNIFORM TORQUE
- PERMITS USAGE OF DIFFERENT SIZES OF SPRINGS IN THE SAME HOUSING FOR DIFFERENT REQUIREMENTS
- SAFER TO INSTALL; BOTH ORIGINALLY AND FIELD REPLACEMENT

**Patent Pending*

For more information on these and other Sandvik Power Springs send for free 12-Page catalog.

SANDVIK STEEL, INC.
Fair Lawn, New Jersey • SWarthmore 7-6200
In New York City • ALgonquin 5-2200
CLEVELAND • DETROIT • CHICAGO • LOS ANGELES

CIRCLE 204 ON READER SERVICE CARD

What's Your Toughest Surface Measurement Problem—

- ☐ Measuring roughness of parts that are
  - ☐ Extra-smooth?
  - ☐ Inside small ID's?
  - ☐ Short or narrow?
  - ☐ Remotely located?
  - ☐ Concave or convex?
  - ☐ Of critical importance?
- ☐ Measuring height and width of waves, bows, steps and other widely-spaced irregularities?
- ☐ Measuring individual pits, flaws, scratches?
- ☐ Measuring waviness around surfaces of rotation?
- ☐ Other:_____

Check and return this, and we'll send free literature on standard or special Profilometer®, Proficorder®, Microcorder® or Wavometer® equipment for the job.

NAME_____ TITLE_____

COMPANY_____ DEPT._____

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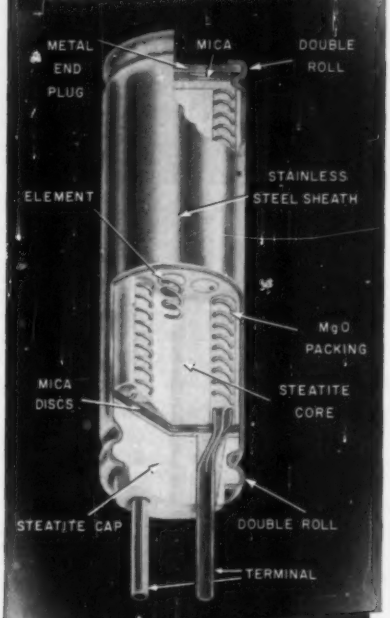
CIRCLE 205 ON READER SERVICE CARD

CIRCLE 80 ON READER SERVICE CARD

HOTWATT®
CARTRIDGE HEATING UNITS...



CONSTRUCTED TO GIVE YOU FASTER, MORE CONCENTRATED HEAT AND LONGER LIFE

- Precision-made stainless steel sheaths for stable, intimate, non-oxidizing contacts with cavities machined for these units.
- Designations are etched — not stamped — on sheath to preserve accurate shape.
- Standard units are moisture-resistant — hermetic sealing on special order.
- Arrangement of heating element assures maximum heat transfer, minimum core temperature, and consequently faster heating.
- Dependable, trouble-free operation.
- Connections are stainless-steel screws and nuts, or standard nickel alloy lead wires swaged to rigid external terminal tubes and insulated by Fiberglas over asbestos — cannot break inside.
- Plus many more standard and special features.

Hotwatt precision cartridge heating units are engineered to provide maximum heat transfer. Each of Hotwatt's construction features complements the others . . . and all are fully integrated to bring you cartridge heaters that insure positive performance under all conditions. And, as an added bonus, Hotwatt's unique manufacturing process assures faster deliveries to your plant.

GET YOUR FREE COPY of this 12-page catalog with all the details on the Hotwatt line. Also included are formulae to aid you in determining wattage capacity required for different materials.

ELECTRIC HEATING SPECIALISTS

HOTWATT, INC.

75 MAPLE ST., DANVERS, MASS.

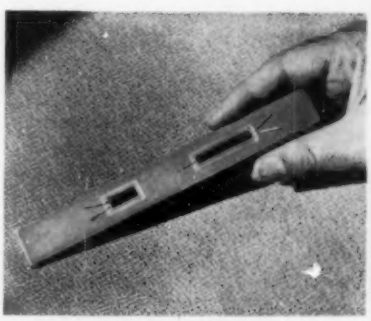
double extra heavy. Available to ASTM specification A-312. Heat exchanger tubes in ⅜- to 1-in. ODs with wall thicknesses from 0.049 to 0.065 in. will be carried in lengths up to 40 ft. Available to ASTM specification A-213 and tolerances to ASTM 269. Seamless products reportedly can be supplied within certain sizes in special shapes, finned and bimetallic form. Carpenter Steel Co, Reading, Penna.

Circle 327 on Reader Service Card

Dry-coil torquemotor . . .

previously available as an integral part of aircraft and industrial servovalves, now is supplied as separate component. Uses a sealing principle that withstands extremely high pressure (up to 6000 psi) and eliminates need for heavy pressure-proof cover over unit. Working fluid is completely sealed from unit's magnetic air gaps, eliminating possibility of magnetic particle contamination. To further protect magnetic air gaps, they are sealed with nonmagnetic material. Four available models have strokes from 0.005 to 0.015 in. and output force from 2.5 to 13 lb. American Measurement & Control Inc, Sub of CompuDyne Corp, 240 Calvary St, Waltham 54, Mass.

Circle 328 on Reader Service Card



Weldable strain gages . . .

provide electrical stability from cryogenic through 750 F. Fully stabilized by heat treating which eliminates need for curing and stabilizing after installation on test pieces. Incorporating special foil gages bonded to 0.005-in. thick stainless steel shim stock, units are made in two basic types: phenolic-bonded constantan foil for up to 500-F service; and ceramic-bonded Nichrome V foil for 750-F continuous service, 1000 F short-term service. Both operate in range of ±½% and have nominal resistance of 120 ohm. Electronics & Instrumentation Div, Baldwin-Lima-Hamilton Corp, 42 4th Ave, Waltham 54, Mass.

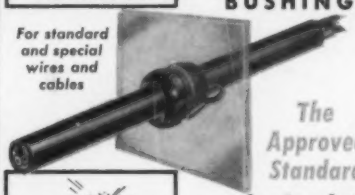
Circle 329 on Reader Service Card

continued on page 84

HEYCO® NYLON BUSHINGS!

HEYCO STRAIN RELIEF BUSHINGS

For standard and special wires and cables



The Approved Standard

for Insulating and Anchoring **ELECTRICAL CORDS & CABLES**

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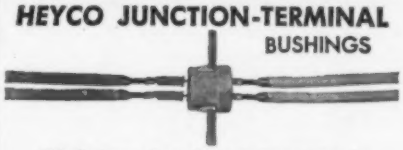
HEYCO

Snap Bushings

Insulation and mechanical protection for electrical wire & cable, hose, tubing & rope—a bearing for moving parts.

Finger pressure snaps and locks bushing into panels of varying thickness up to ⅛"

HEYCO JUNCTION-TERMINAL BUSHINGS



Miniature Insulated Receptacle

Eliminate "Pig-Tail" Wire Leads
Mate with 3/16 or 1/4" female terminals

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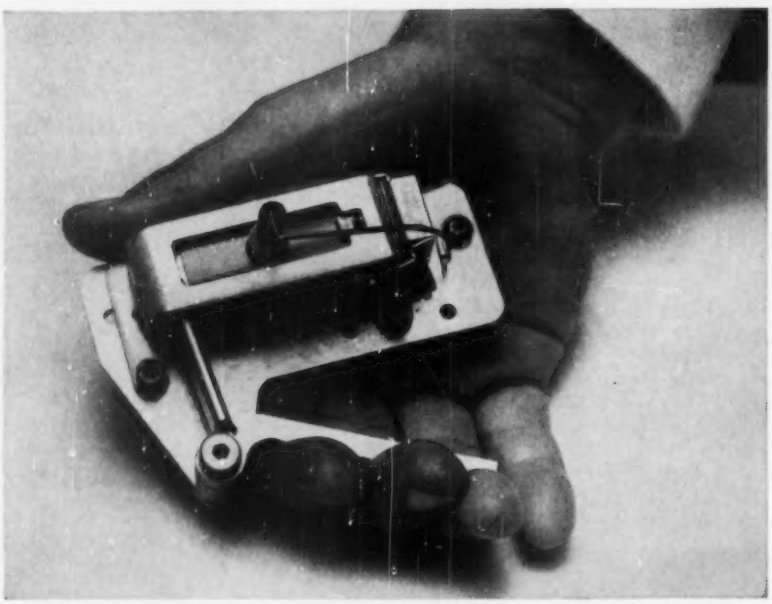
KENILWORTH 3, NEW JERSEY

FREE SAMPLES: Which bushings would you like?

the LEAD newsletter

Vol. 3 No. 2



Exciting new roles for lead are brought sharply into focus with the introduction of a new ignition system, smaller than a man's fist, that develops a 20,000-volt spark through the application of pressure to two small chunks of a ceramic, lead zirconate-titanate.

The system—dubbed the "spark pump"—does the job of coil, points, condenser and magneto, is already in use in engines of 2¾ to 6½ horsepower for lawn mowers, portable generators, sprayers and pumps for farm and industry.

This application, however, is only the beginning.

Old Phenomenon...New Versatility

The basic principle—direct conversion of mechanical to electrical force (or piezoelectricity)—was discovered in 1880 by Pierre and Jacques Curie, who worked with various crystals.

The discovery, in 1940, that certain ceramics could be permanently polarized promoted the development of piezoelectric ceramics in sizes and shapes not possible with crystals. In the 1950's it was found that the upper temperature limit of these ceramics (about 100° C) could be overcome through the use of lead zirconate-titanate, with limiting temperature around 300° C.

Not only is this lead-based product (65% lead oxide) the most efficient and highest temperature piezoelectric material yet developed, it is also the first successfully to resist depoling under the high pressures necessary.

From Ultrasonics To Fishing

Piezoelectric ceramics for use in ultrasonic cleaning devices are now in large-volume production. Another expanding product area is sonar—underwater counterpart of radar in air—applied militarily for sound-detection, and commercially for locating fish. Depth-finders for pleasure boats are another present sonar application holding promise of growth for the future.

Also currently employing lead-based ceramics of piezoelectric properties are phonograph cartridge elements, fuse elements for detonators, microphones, delay lines, and accelerometers for measuring vibration.

New Ideas By Dozens

Ideas for new products based on the ceramics, says one producer, are coming up so rapidly that merely assessing their merit is quite a sizeable problem. One suggestion: imbed a piece of ceramic in the heel of women's shoes. Each step would generate a spark and light a neon bulb. To what beneficial purpose, the idea's originator does not say—but, women's fashions being what they are, even this notion might sell.

Other ideas, more generally promising, include: spark ignition for oil and gas furnaces, gas stoves and clothes dryers ...electrostatic air filters...atomization of fuel oil...speedometers...and, of course, "spark pump" devices for various gasoline engines, including automotive.

Possibilities In TV Tubes

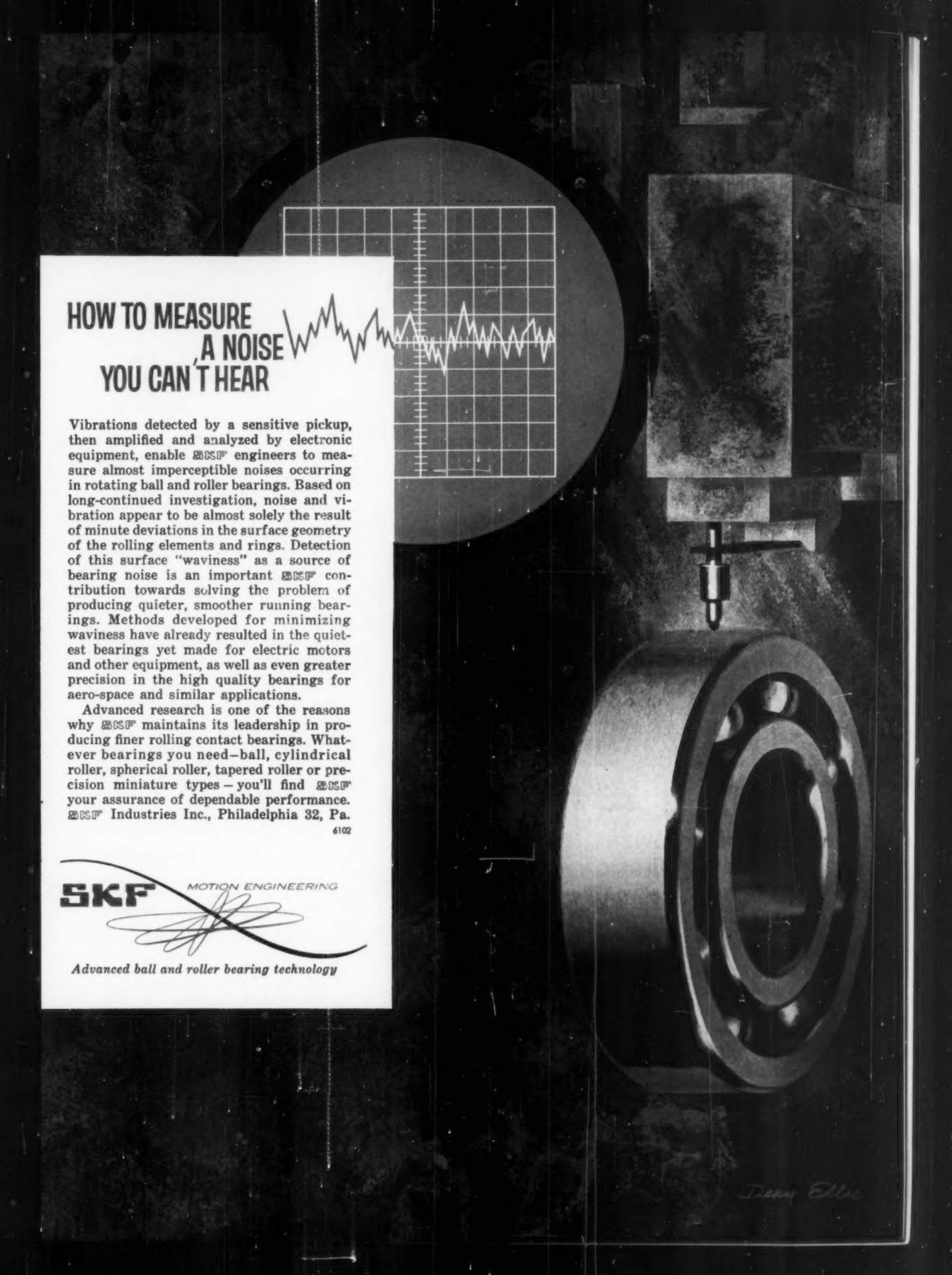
One of the largest electronic companies recently announced a successful experiment with lead-based piezoelectric ceramic sheet stock. By coating the surface with a luminous material, they were able to excite the ceramic electrically and produce visual figures on the surface as in a cathode ray tube. It takes little imagination to visualize the TV picture tube of the future hanging from the wall in a picture frame.

New uses for lead and its many compounds are continually being explored by L.I.A. For technical information and assistance on this and other applications of lead both old and new, outline your areas of special interest in a letter to: Office of Technical Information, Lead Industries Association, 292 Madison Avenue, New York 17, New York. 4479

LOOK AHEAD WITH LEAD

CIRCLE 82 ON READER SERVICE CARD

CIRCLE 83 ON READER SERVICE CARD→



HOW TO MEASURE A NOISE YOU CAN'T HEAR

Vibrations detected by a sensitive pickup, then amplified and analyzed by electronic equipment, enable SKF engineers to measure almost imperceptible noises occurring in rotating ball and roller bearings. Based on long-continued investigation, noise and vibration appear to be almost solely the result of minute deviations in the surface geometry of the rolling elements and rings. Detection of this surface "waviness" as a source of bearing noise is an important SKF contribution towards solving the problem of producing quieter, smoother running bearings. Methods developed for minimizing waviness have already resulted in the quietest bearings yet made for electric motors and other equipment, as well as even greater precision in the high quality bearings for aero-space and similar applications.

Advanced research is one of the reasons why SKF maintains its leadership in producing finer rolling contact bearings. Whatever bearings you need—ball, cylindrical roller, spherical roller, tapered roller or precision miniature types – you'll find SKF your assurance of dependable performance. SKF Industries Inc., Philadelphia 32, Pa.

6102

SKF MOTION ENGINEERING

Advanced ball and roller bearing technology

CIRCLE YOUR INTEREST

Bending • Steering • Locking
Indexing • Controlling • Clamping
Turning • Lowering • Opening • Lifting
Shifting • Tilting • Driving • Valve Operation
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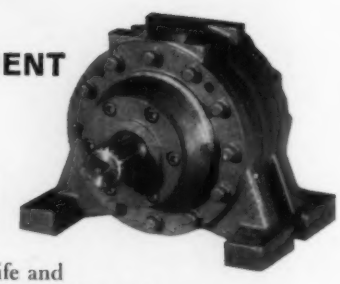
AND LET HOUDAILLE'S

HYDROAC

CATALOG SHOW
YOU THE MOST EFFICIENT
WAY TO TURN
HYDRAULIC POWER
INTO ROTARY ACTION



HydRoAc's high quality means long life and low internal leakage... Expect efficiencies to 95% and over with these compact and powerful high-pressure hydraulic rotary actuators... Unlimited commercial applications range from turret lathes to farm machinery... Instantaneous torque in both directions... Rated operating pressure 3000 p.s.i.... Foot or end mounted... Designing a new product or re-designing an old one... get the Houdaille HydRoAc story first!

... Specialists in rotary type hydraulic equipment

Houdaille Industries, Inc.

Buffalo Hydraulics Division • Dept. C • 537 E. Delavan Ave., Buffalo 11, N. Y.

360-sided optical polygon . . . optically checks alignment and angular spacing in any multiple of full degrees and is said to be accurate to within 0.000012 in. at a 20-in. dia. When used with an autocollimator or similar optical sighting device, unit provides an accurate mirror surface which reflects projected image of sighting device's cross hairs. Amount of deviation between reflected image and graduated cross hairs in sighting device gives geometric check on misalignment, parallelism, angularity, etc. **Michigan Tool Co, 7171 E McNichols Rd, Detroit.**

Circle 330 on Reader Service Card

Hi-flow polypropylene grades permit max cycle retention by faster filling of even most complex molds. Flow characteristics also allow easier molding of thin-wall sections and help reduce molded-in stresses. Grades 107 and 117 have identical melt index—12 at 446 F—but latter contains only additives approved by FDA. Both are priced at 42¢ per lb in 20,000-lb lots and in natural color. Also can be supplied in variety of colors. Standard packaging is in 50-lb multi-wall lined paper bags. **Enjay Chemical Co, 15 W 51st St, New York 19.**

Circle 331 on Reader Service Card

Polyester-base strain gage has grid dimensions of $\frac{1}{16}$ x $\frac{1}{4}$ in. and can be installed with adhesive at room temperature within 20 min. Operation is possible to 400 F without elevated temp cure. From stock. **Metrix Inc, PO Box 683, Walnut Creek, Calif.**

Circle 332 on Reader Service Card

Recorder-tester . . . is portable instrument for testing ac voltage and current conditions. Switch on front panel selects three voltage ranges (0-150, 0-300, and 0-600 v) and four current ranges (0-15, 0-30, 0-60 and 0-150 amp). Can be used for direct reading or

recording at twist of knob. Carries enough chart paper for continuous monitoring of either line voltage or current for 31 days. Standard chart speed is 1 in. per hr. Other chart speeds available by change of gear trains: 2, 3, 6, 10, 12, 15, 30 or 60 in. per hr. Priced at $195. **Rustrak Instrument Co, 130 Silver St, Manchester, NH.**

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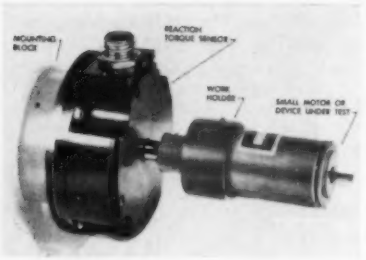


Torque sensor . . .

is suitable for measuring small motor, stepping switch, rotary solenoid and drilling torques; bearing friction; torsion spring, etc. Measures torque by restraining case of test device. Said to provide true dynamic torque with top frequency response by eliminating need for in-line torque sensor which changes rotating inertia of system being tested. Standard models are available in capacities of 0-10, 0-50, 0-100, 0-200, 0-500, 0-1000 in. oz with ¼% accuracy. **Lebow Associates, 14857 W Eleven Mile Rd, Oak Park 37, Mich.**

Circle 334 on Reader Service Card

X-Y recorders . . .

include rack-mounted and cabinet instruments which operate with dc input only. Draw cartesian coordinate curves automatically from dc electrical information and plot one variable against time. Input voltage ranges are calibrated in 16 steps from 0.5 mv/in. to 50 v/in. on each axis. Variable range feature provides means for continuously varying max span of each step to any scale factor within instrument's voltage limits. Low pass filters remove extraneous noise when plotting dc signals. Pens speeds are 20 in./sec for each axis. Cabinet model is priced at $1950; rack-mounted model, $1975. **F L Moseley Co, 409 N Fair Oaks Ave, Pasadena, Calif.**

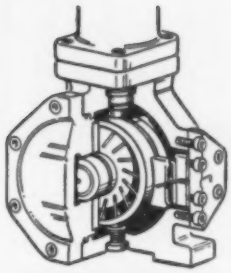
Circle 335 on Reader Service Card

Metal foil samples . . .

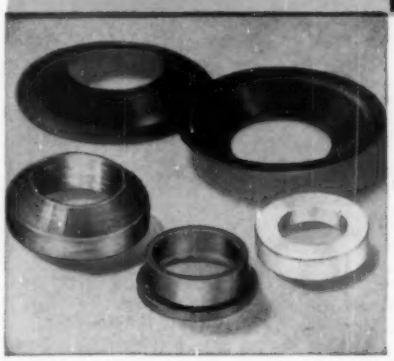
measuring 3 x 7 in. in thicknesses from 0.000125 to 0.0005 in., include following alloys: beryllium copper, stainless steel, 4-79 Moly Permalloy, copper and Havar. Binder containing samples is priced at $10. **Precision Metals Div, Hamilton Watch Co, Lancaster, Penna.**

Circle 336 on Reader Service Card

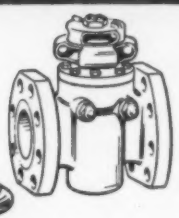
FOR:
Guide Bushings, Vanes and Wear Rings



HAVE YOU CONSIDERED THE IMPORTANT ADVANTAGES OF FILLED TEFLON*?



Formed Gaskets



Valve Seats and Packings

It has been definitely established that the value of Teflon can be considerably enhanced by the use of fillers in certain applications. Laboratory and field experience has demonstrated that the use of fillers permit Teflon to be more readily tailored to a wide variety of chemical, electrical and mechanical applications. Also, some mechanical properties can be improved. These include:

1) resistance to deformation under load
2) resistance to wear
3) thermal conductivity
4) compressive strength
5) hardness

By thus improving its properties, Teflon now offers even greater industrial potential. This is the reason filled Teflon has become an important item in the "John Crane" Chemlon® line of better Teflon products.

Chemlon is available with such fillers as glass fiber, carbon, graphite, copper and bronze, talc, calcium fluoride and other inorganic materials.

Tell us about your requirements. We'll tell you the advantages you can get from filled Chemlon. Request Bulletin T-104.

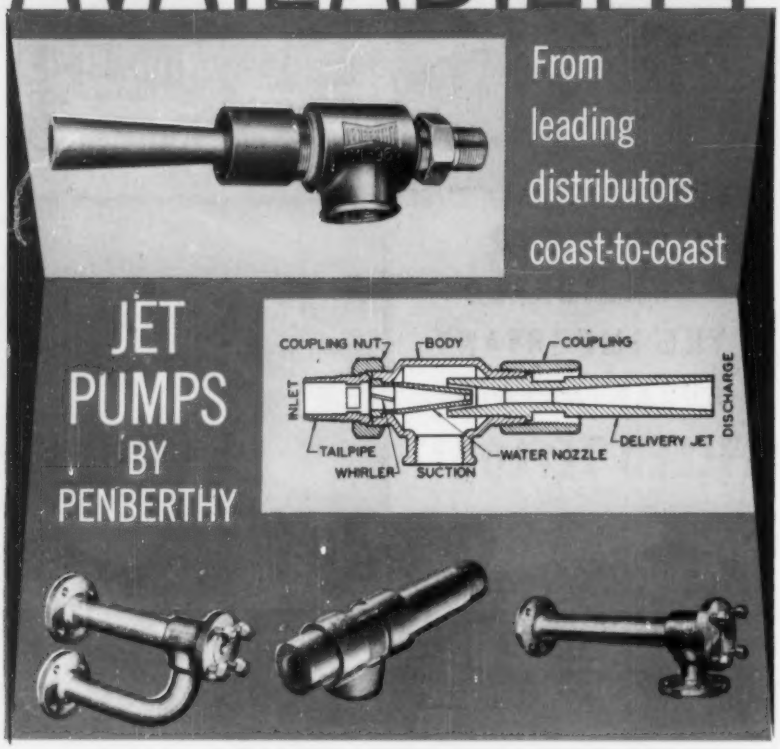
Crane Packing Company, 6445 Oakton Street, Morton Grove, Illinois, (Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ont

* *DuPont Trademark*

John Crane

CRANE PACKING COMPANY

AVAILABILITY



When you want something . . . like a jet pump, for example . . . you *want* it. Not day after tomorrow, or next week, but *now!* Right? And that's just one more advantage of Jet Pumps by Penberthy. Availability . . . *now.*

Penberthy, to begin with, has a broader line with more models and sizes to offer . . . hydraulic, air or steam operated . . . in bronze, iron, stainless steel, monel, plastic and other materials. Penberthy, in addition, offers "standards" on many designs that would be labeled "special" by other manufacturers.

Add to the above, Penberthy's nationwide network of representatives and stocking distributors. They're located in all the major metropolitan areas so, chances are, there's a Penberthy man near you. Be happy to supply his name and address . . . write or call the Penberthy sales office at the address below . . .

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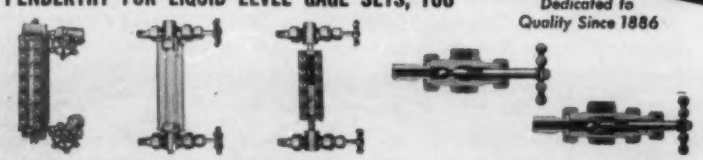
Dedicated to Quality Since 1886

PENBERTHY FOR LIQUID LEVEL GAGE SETS, TOO



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FORMULA FOR FLEXIBLE ANALYSES

LOOKING FOR A SPECIAL COMPOSITION in your steel tubing... perhaps in limited quantities? Then ACIPCO is the ideal source! Here are complete facilities plus the newest process*... ACIPCO CERAM-SPUN®... for producing centrifugally spun tubes to meet the most rigid specifications.

CONSIDER THESE ADVANTAGES: 1. Electric furnaces, both arc and induction type, are available in a variety of capacities... heats can be sized to produce the exact footage required. **2.** With minor modifications for castability, all carbon and low alloy steels can be furnished in compliance with the chemical composition limits of SAE and AISI Standards. Special ferritic chromium-molybdenum alloy steel tubes are manufactured to meet the requirements of ASTM Specification A426-58T. **3.** All ACI corrosion resistant and heat resistant alloys... as well as Cast Monel and ARMCO 17-4 PH.. are available. **4.** Also, gray and alloy cast iron and all grades of AMERICAN DUCTILE IRON® (including the austenitic grades) are regularly cast as pipe, tubes, fittings and specials in all sizes and thicknesses.

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If you design, manufacture or use parts requiring tubular metal components, it will pay you to investigate the other advantages ACIPCO offers. For complete facts, contact ACIPCO STEEL PRODUCTS, Division of American Cast Iron Pipe Company, Birmingham 2, Alabama.

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Dura Seal is the most extensive line of mechanical seals offered to industry today . . . meeting a wider range of pressures, temperatures and liquids.

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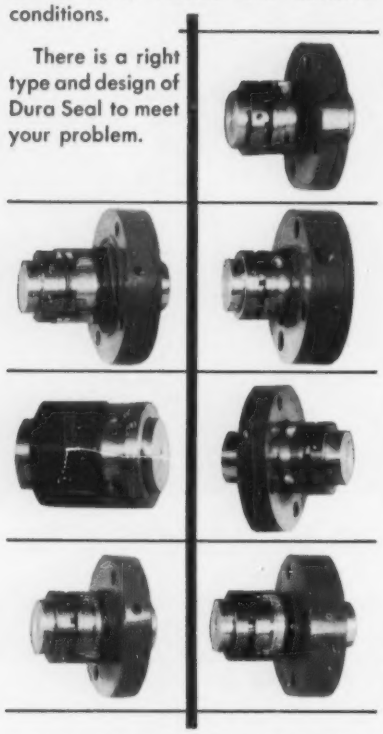

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DESIGN LITERATURE

Metals Handbook— 8th edition, Vol 1— Properties and Selection of Metals

American Society for Metals, Novelty, Ohio. 8¼ x 10⅞, 1300 pp. $30.

The new ASM Metals Handbook is devoted exclusively to the selection and properties of metals and is the first of a projected series of volumes which, when completed, will cover all branches of metals engineering and metalworking. Of particular interest to the designer, this volume not only provides the largest single storehouse of reliable information about metals but also emphasizes the factors of economy and fabricating in metals selection. More than 1300 metals specialists are named as contributors to the volume. There are 6700 illustrations, 1841 tables, over 1500 examples, 2806 definitions and data compilations on 456 alloys.

An enlarged section on carbon and low-alloy steels consists of 26 major articles—12 on steel products and 14 on selection for specific engineering properties, economy, and special processing considerations. This section covers all commercial steel product forms, with an appendix on the design of steel springs, and special articles dealing specifically with selection for maximum yield strength at minimum cost, hardenability, fatigue resistance, notch toughness, wear resistance, and resistance to corrosion.

Many articles dealing with metal selection for specific engineering properties are new. The section on stainless steels now provides coverage of all stainless steels (cast and wrought), including the more recently developed precipitation-hardening alloys. Aluminum, copper and the other major nonferrous metals are amply covered. Other sections are devoted to iron-base super-strength alloys, nickel-base and cobalt-base alloys, titanium and titanium alloys. More pages are assigned to magnetic, electrical, and other special-purpose metals, precious metals, and—a subject of rapidly expanding interest to designers — the properties of pure metals. A glossary of 2800 definitions appears at the front of the book. —FRP

"We interrupt your picture temporarily to bring you a few words from our sponsor."

Modern Physics for the Engineer

L N RIDENOUR & WM A NIERENBERG. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 9¼ x 6¼, 383 pp. $9.50.

The present volume comprises a second series of lectures, coordinated by Dr William Nierenberg, and given during the academic year 1957-1958 at various institutions throughout the state of California.

Following the technical organization of the earlier volume, it is divided into three main parts, dealing respectively with the laws of nature, man's physical environment, and technology. The contributors are all acknowledged experts in their fields. Contents and authors include: New Particles and Old Principles, by Emilio Segre; Status Report on New Particles, by Luis W. Alvarez; Nuclear Shell Structure, by Maria G. Mayer; Electron Scattering and Nuclear Structure, by Robert Hofstadter; Electrons and Nuclei in Ideal Crystals, by W. V. Houston; Properties of Liquid Helium, by John R. Pellam; Superconductivity, by M. Tinkham; Magnetohydrodynamic Waves, by Alfredo Banos Jr; Origin of Nuclear Species by Means of Nuclear Reactions in Stars, by William A. Fowler; Radio Astronomy, by Ronald Bracewell; Origin of the Earth's Mag-

continued on page 91

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Skinner has a complete range of Explosion-Proof Solenoid Valves

If you have a control problem involving valves operating in hazardous locations—Class I Group D (gasoline vapors, etc.), Class II Group F (coal and coke dust) and Group G (grain dust)—you can select from Skinner's complete line of two- and three-way explosion-proof standard and high pressure solenoid valves.

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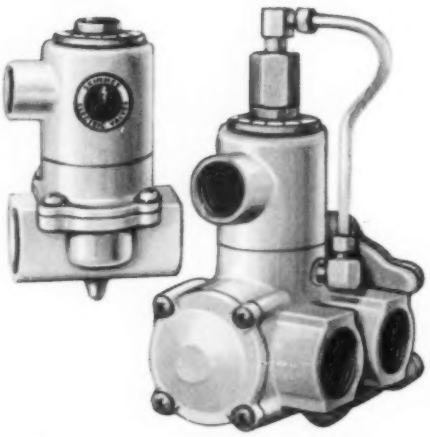

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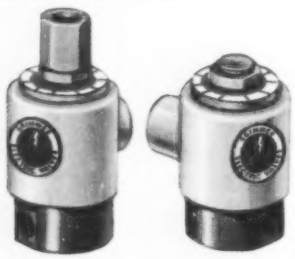
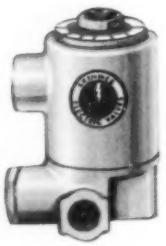


Two-way solenoid valves are available normally closed, normally open and dual purpose. Orifice sizes from $\frac{1}{32}$″ to $\frac{3}{8}$″, maximum operating pressure differential 3000 PSI depending on orifice size—NPT pipe size $\frac{1}{8}$″, $\frac{1}{4}$″ and $\frac{3}{8}$″.

Three-way available normally closed, normally open, directional control and multi-purpose. Orifice sizes from $\frac{3}{64}$″ to $\frac{1}{4}$″, maximum operating pressure differential 200 PSI depending on orifice size.

TWO-WAY PISTON TYPE SOLENOID VALVES—XR SERIES

These valves, with forged naval brass body and stainless steel piston, handle high flow and high pressure requirements of industrial and commercial applications with most common media.



XR series valves are available with $\frac{1}{4}$″ orifice and $\frac{1}{4}$″ NPTF in normally closed or normally open construction. Operating pressure differential 5 to 1250 PSI for AC operation and 5 to 1000 PSI for DC operation.

TWO- AND THREE-WAY HIGH FLOW SOLENOID VALVES—XL SERIES

These diaphragm type solenoid valves meet the high flow requirements of a great many commercial and industrial applications. The unique Skinner diaphragm construction makes possible the exceptionally long service life of this series valves.

Two-way XL series valves are available normally closed and normally open. Orifice sizes are $\frac{1}{2}$″, $\frac{3}{4}$″ and 1″ with corresponding NPTF pipe connections. The $\frac{1}{2}$″ orifice model is also available with $\frac{3}{8}$″ NPTF. Operating pressure differential is 5 to 150 PSI.

Three-way XL series valves are available normally closed, normally open and directional control. Orifice sizes are $\frac{3}{8}$″, $\frac{1}{2}$″ and $\frac{3}{4}$″ with corresponding NPTF pipe connections. Operating pressure differential is 5 to 150 PSI for the $\frac{1}{2}$″ and $\frac{3}{4}$″ size and 10 to 150 PSI for the $\frac{3}{8}$″ size.

TWO- AND THREE-WAY HIGH PRESSURE HYDRAULIC SOLENOID VALVES—X10 SERIES

These stainless steel, direct acting, slide-type valves are precision engineered to control hydraulic systems at pressures up to 2000 PSI.

These high pressure hydraulic valves have a $\frac{3}{32}$″ inlet and cylinder orifices with $\frac{1}{8}$″ NPT. They can be used as two-way normally closed or two-way

normally open valves by plugging the appropriate port, and three-way normally closed, or three-way normally open, or dual purpose valves.

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netic Field, by Walter M. Elsasser; Controlled Thermonuclear Fusion, by S. A. Colgate and H. F. York; Nuclear Reactors—a Novel Technology, by Mark Mills; Particle Accelerators, by Robert R. Wilson; and Frontiers of Aerodynamic Research, by Ronald Smelt.

Other Books of Interest

ASTM Standards: Methods of Testing Metals
American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6 x 9, 180 pp. $4.

Handbook of Noise Measurement
A P G Peterson, E E Gross. General Radio Co, West Concord, Mass. 7 x 10, 100 pp. $1.

Axiomatics of Classical Statistical Mechanics
R Kurth. Pergamon Press Inc, 122 E 55th St, NY 22. 5½ x 8¾, 180 pp. $7.50.

ABSTRACTS FROM THE LITERATURE

Underground Cathodic Protection

An account is given of various methods used by a telephone company to minimize the corrosion of lead sheathed underground communication cables. Controlled drainage connections were established into all d-c railway substations, forced drainage systems set up to overcome and effects and use made of rectifiers, magnesium anodes and magnesium ribbon to overcome anodic conditions.

Utility structures were consistently insulated from each other. Insulation joints were used at building entrances, resistance bonds were avoided at pipe line crossings and insulators used in anchor guys. But the advantages of isolation will soon need reconsideration in view of the growing tendency to interconnect telephone cable sheaths and power company multigrounded neutral systems.

"Methods and Experience in Underground Cathodic Protection," by Oliver Henderson, foreign wire relations engineer, The Ohio Bell Telephone Co, Cleveland, Corrosion, Jan 1961. National Association of Corrosion Engineers, 1061 M & M Bldg, Houston 2, Texas.

Detecting Flaws

The days when sample, or suspect, castings, etc., had to be cut up and destroyed in checking for blowholes or other internal defects have passed—nor are methods of destructive testing good economics under present production conditions. Nondestructive flaw testing techniques have developed from the radiograph to embrace fluoroscopy, now available as a practical industrial technique, and ultrasonic testing which lends itself, in particular, to fully automatic operation if necessary. Magnetic particle testing, however, still retains its place and all four methods are evaluated in this article.

"The Scope of Flaw Detection," Mechanical World, July 1960, 31 King St. W., Manchester 3, England.

Tin and Its Uses

Anti-friction bearings containing 6% of tin, remainder aluminum, are now being made in France from rod which has been continuously cast. The advantages of this method of casting are that the structure of the tin-aluminum alloy has excellent anti-friction qualities, combined with high strength, and the material can be used for solid bearings without a steel backing.

Although tinplate containers are used in their thousands of millions this is only possible thanks to the most careful methods of control of the material, both in its manufacture and usage. Some of the intricacies of the study of these problems are described in an article entitled "Resistance of Tinplate to Rust and Corrosion".

There is also an article on the value of employing both zinc and tin together as electro-plated coatings upon steel exposed to severe weather conditions.

Perfection in soldering is a "must" for the electronic industries and an article in this issue of "Tin and its Uses" discusses the merits of various types of pre-treatments of parts which have to be soldered and suggests a combination of electro-plating with pure tin, followed by fusion of the coating, which may be the practical answer in many instances.

"Tin and Its Uses," Quarterly Journal of the Tin Research Institute. Fraser Road, Greenford, Middlesex, England, Oct 1960.

Lubrication Literature

First of two-part digest of literature for 1959-60 covers friction and wear, boundary lubrication, metalworking lubricants, and automotive lubricants.

"Lubrication Review," M. B. Peterson, General Electric Co. Mechanical Engineering, April 1961, 29 W 39th St, NY 18.

DC Dynamic Braking

To find out how long it will take to stop a given inertia it is necessary to know the variation of braking torque with speed for various values of dc excitation. The author shows how to calculate braking torque, using the standard induction motor equivalent circuit and a simple graphical technique, and confirms the method with tests on a typical induction motor.

"How Much Torque from DC Dynamic Braking?", Robert C. Moore, Allis-Chalmers Mfg Co. Control Engineering, April 1961, 330 W 42 St, NY 36.

Metal-bellows Seals

A metal bellows can be incorporated in an end-face-type seal. Temperature extremes or gamma radiation dictate the use of a metal bellows in such a seal. When able to calculate

continued on page 92

"Sometimes I don't have too much confidence in your group."

"Boy! What a day! They just took Charlie Frimly away in a net!"

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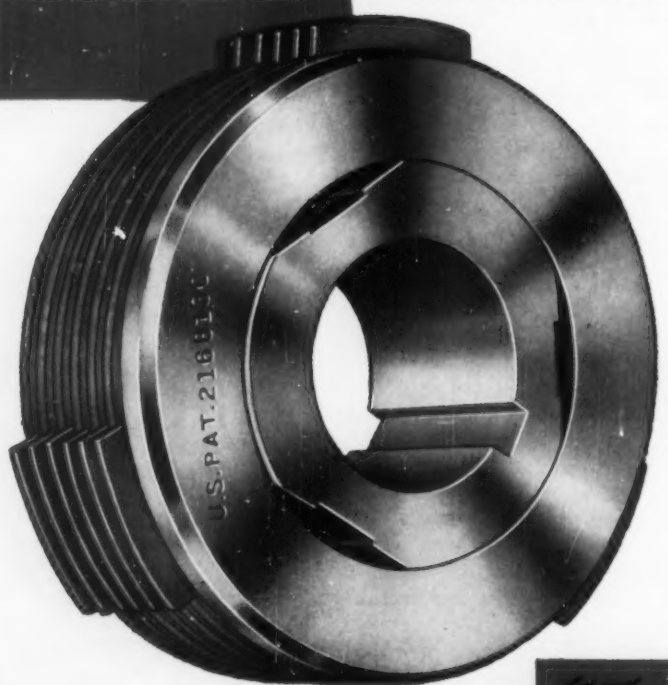

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the spring rate of the bellows, the seal designer can set the proper sealing face load. The bellows seal design is not complete until the effects of temperature, pressure, and mating ring wobble are taken into full account.

"Metal Bellows Seals," by R. W. Blair, D. L. Johnson and J. P. Morley, Chicago Rawhide Manufacturing Company, Chicago. Presented at the 16th ASLE Annual Meeting, Apr '61, Philadelphia.

Selecting Spring Materials

Discusses selection of superalloys for springs to meet the demands of high-temperature applications.

"Selecting the Right Spring Material Is Easy When You Follow These Rules," V. A. Stanton, National-Standard Co. Design Engineering, May 1961, 481 University Ave, Toronto 2, Canada.

Air Lubrication— a Development Tool

The advantages of air lubrication and positioning are applied to devices and systems in the early stages of their development. It is during these preliminary evaluations that the feasibility of proposed ideas and processes must be proven. The use of air-lubrication techniques as a development tool to provide the most favorable auxiliary test conditions is demonstrated. It is shown that the confidence with which developmental programs can proceed, when implemented by air-lubrication techniques, justifies the use of air in many feasibility models even though air supplies may be unavailable for, or many later prove to be unnecessary for, subsequent prototype designs. Specific applications of air lubrication in the electronics industry are discussed.

"Air Lubrication—A Development Tool," Martin L. Levene, Radio Corp of America. American Society of Mechanical Engineers, 61-LUBS-13, 29 W 39th St, NY 18.

Double Electrical Insulation

The rapidly widening practice of providing two insulation barriers in such products as portable appliances is discussed. These types of insulation are identified as: (1) primary or "functional" insulations, between motor windings and field and armature cores or between current-carrying parts and adjacent metal parts; (2)

continued on page 95

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We've become the biggest in the investment casting field...

No investment casting job has ever been or ever will be too small for us.

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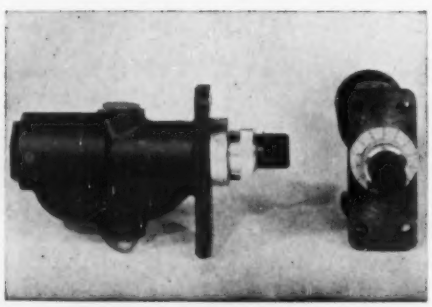

controls Flow as low as 2 cubic inches per minute. Accuracy of ±10% over a pressure differential of 1000 psi at 2 CIPM.

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secondary or "protecting" insulation, between armature and field cores or metal parts adjacent to current-carrying parts and external metal parts. This secondary barrier is designed to provide protection in event of failure of primary insulation.

Schematic diagrams of insulation systems are included as well as the text of regulations proposed by the Electric Appliance Industry Committee. A number of bibliographical references are also given.

"Double Insulation in Portable Appliances," D. C. Krammes, The Hoover Co. American Institute of Electrical Engineers, 29 W 39th St, NY 36.

Abrasion and Wear Resistance of Reinforced Polyester Surfaces

Reports exhaustive testing by all known methods, employing all known variables. It also points out the fact that added test methods are needed before test results can be correlated to actual service life.

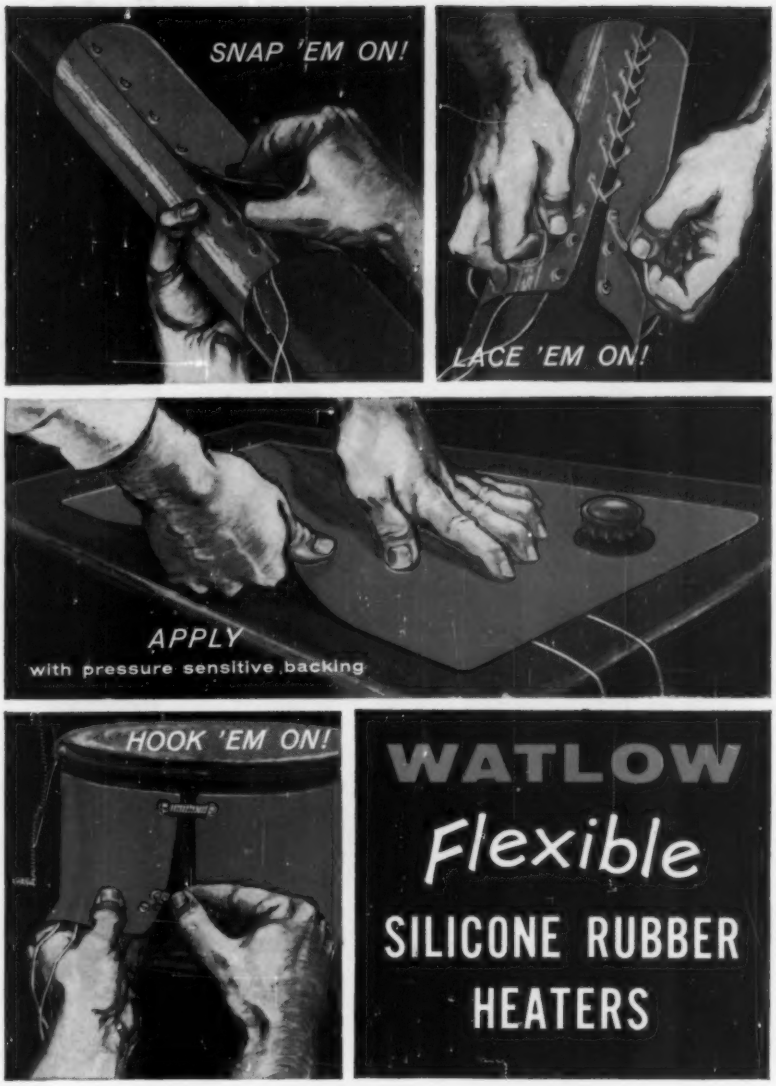
"Abrasion and Wear Resistance of Reinforced Polyester Surfaces," C. B. Sias, Pittsburgh Plate Glass Co. Plastics Technology, March 1961, 630 Third Ave, NY 17.

Magnetic Journal Bearing

The supporting of a rotating shaft in such a way that no material contact is made with the shaft can be of importance for technical applications. Cases in point are where the friction or wear must be particularly small, where contamination by lubricants is inadmissible or where the lubricating oil would decompose under the influence of radiation (in a nuclear reactor,

continued on page 97

"Do you happen to have five bucks you could let me . . er . . . . ah . . now, about this drawing, Charlie . . . ."



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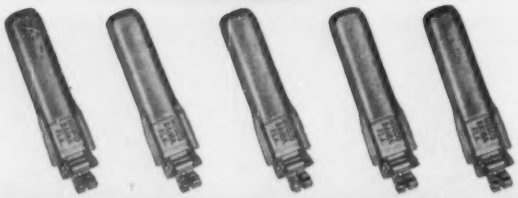

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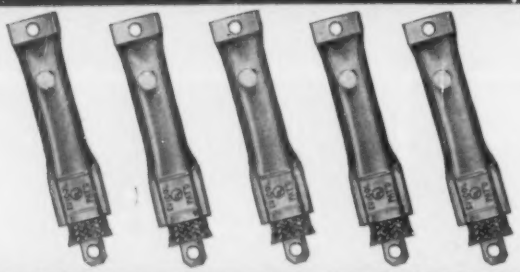

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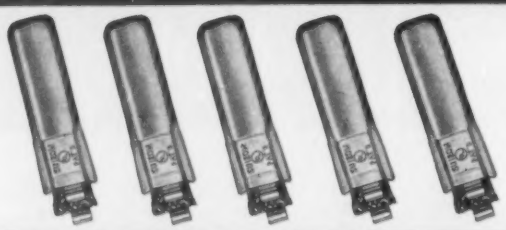

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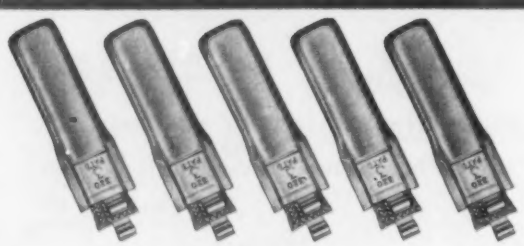

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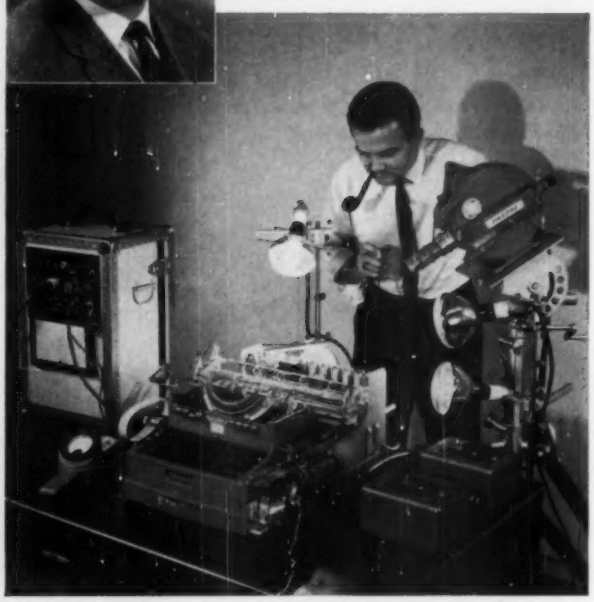

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for example). The article considers the theory of a shaft held in suspension by magnetic fields, and compares the theory with the results of measurements made on "magnetic bearings" of various dimensions.

"A Magnetic Journal Bearing," by F. T. Backers. Philips Technical Review, No. 7, Vol. 22, 1960/61, p 232.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 103.

TIME CONTROLS—Manual, 70 pp. Begins with explanation of time controls and circuitry and progresses to complex application diagrams. Among subjects covered: basic construction of time controls; explanation of switches and circuits; function and operation of elapsed time indicators, and cycle, interval, time delay and reset timers. Haydon Div, General Time Corp, Torrington, Conn.

Circle 350 on Reader Service Card

ELECTRICAL MACHINERY—Bulletin E100P, 48 pp. Presents, in question and answer form, theoretical and practical features of common types of dc and ac motors, generators and control equipment. Highlights electrical terminology and phenomena and is widely illustrated with electrical rotating machines and allied equipment. Fairbanks, Morse & Co, Electrical Div, Dept EB, 303 N Henderson, Freeport, Ill.

Circle 351 on Reader Service Card

COATED STEELS—Brochure, 12 pp. Deals with continuous hot dip coat, bright zinc, special alloy coat, electro-galvanized and painted and printed strip steel. Details size ranges, forming, welding, soldering, cleaning, chemical treatment, temper classifications and Preece tests. Illustrations depict typical applications. Sharon Steel Corp, Sharon, Penna. Copies available from Arthur Schmidt & Associates, 342 Madison Ave, New York 17.

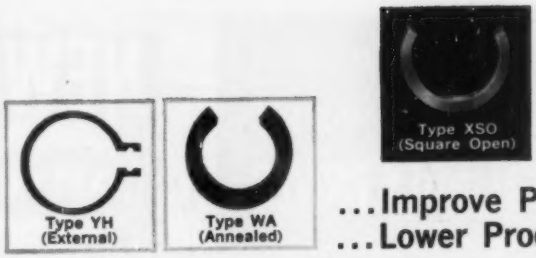
Circle 352 on Reader Service Card

HOLDING MAGNETS—Engineering bulletin, 4 pp. Explains simplified method for designing holding magnets and assemblies and includes 24 basic designs and their performance characteristics. Indiana Steel Products Div, Indiana General Corp, Valparaiso, Ind.

Circle 353 on Reader Service Card

CARBON, GRAPHITE FOR HI-TEMP USES—Bulletin C-613, 6 pp. Reviews unusual properties of various grades and their application in machining molds, dies,

continued on page 99



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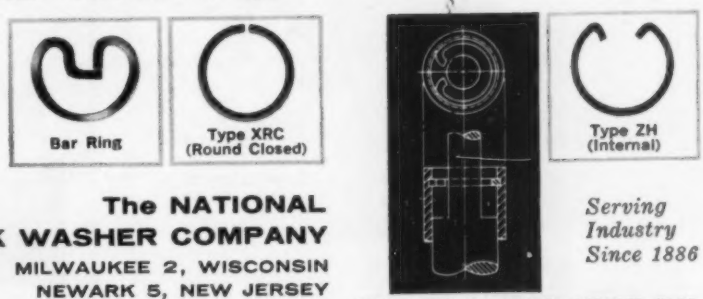

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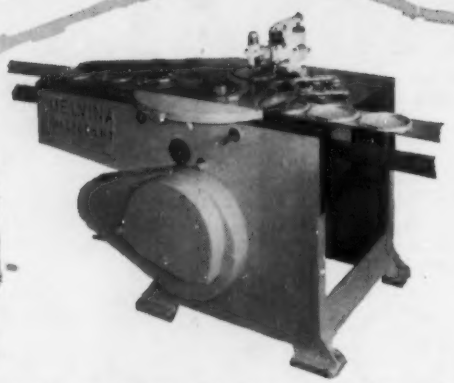

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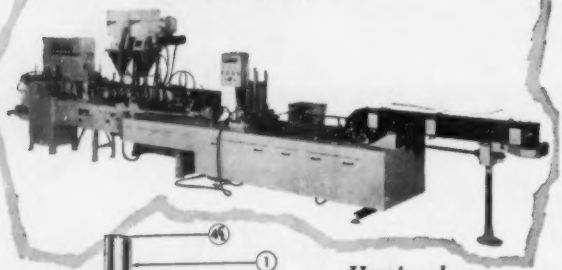

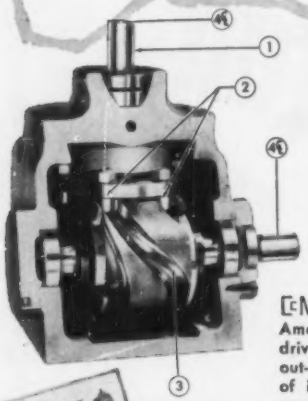

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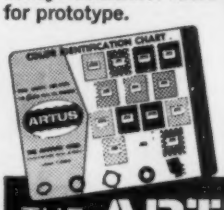

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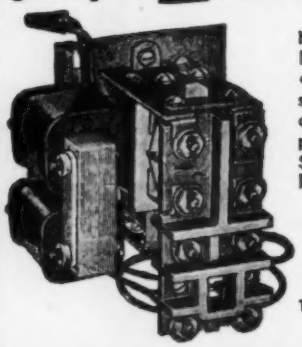

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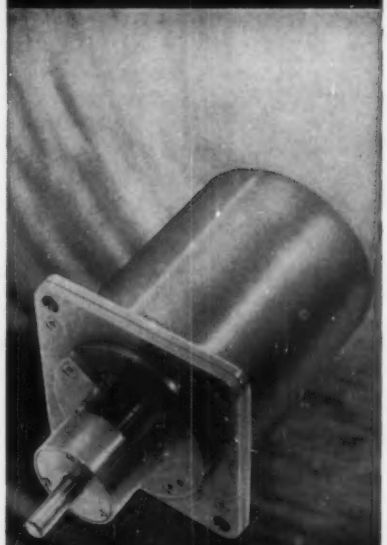

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DESIGN LITERATURE.....continued

crucibles, sintering boats and other items that require resistance at hi-temps. Chart lists commonly used types and grades, possible size ranges and physical and chemical properties. Speer Carbon Co, St Marys, Penna.

Circle 354 on Reader Service Card

PUMPS AND ACCESSORIES—Nine bulletins. Carry design features, specifications, dimensions, dimension drawings and photographs of complete line, including vertical duplex and horizontal triplex models, as well as a high-pressure washing unit. Industrial Sales Dept, Jean Bean Div, Food Machinery & Chemical Corp, Lansing 4, Mich.

Circle 355 on Reader Service Card

MOTOR STARTERS—Bulletin GEA-7321, 4 pp. Describes, gives outline dimensions, ordering directions and prices of combination safety magnetic motor starters that protect against unauthorized entry and personnel injuries. Callout photo illustrates safety device, and sequence photos show how to perform inspection or maintenance with or without power interruptions. General Electric Co, Schenectady 5, NY.

Circle 356 on Reader Service Card

MICA SUBSTRATES AND PRINTED CIRCUITS—Bulletin, 4 pp. Contains drawings illustrating fabrication and application of these components, as well as graphs and diagrams covering electrical characteristics. Property chart details general, electrical and mechanical characteristics of all grades of glass-bonded mica in standard forms. Includes available sizes and sheet prices. Electronic Mechanics Inc, 101 Clifton Blvd, Clifton, NJ.

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SEMICONDUCTORS—8½ x 11-in. card. Features "reliability" nomograph with which user can predict success rate from life test data at a 90% confidence level. Also computes sampling plan for conventional risks. Scales, tables and glossary of terms are included. Raytheon Co, Semiconductor Div, 215 1st Ave, Needham, Mass.

Circle 358 on Reader Service Card

FLAT-TOP ROLLER CHAIN—Bulletin 9, 4 pp. Describes performance features of thermoplastic top plate chain and provides sizes and prices. Acme Chain Corp, 821 Main St, Holyoke, Mass.

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OVERLOAD PROTECTOR—Bulletin GEA-7030, 2 pp. Discusses features and advantages of unit for appliance motors with up to 50-amp locked rotor current. Supplies selection and application informa-

continued on page 101

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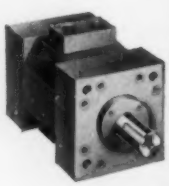

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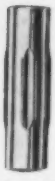

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tion, as well as cross-section view and graph depicting overload protection under typical conditions. General Electric Co, Schenectady 5, NY.

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SIGHT FLOW INDICATORS—Bulletin, 2 pp. Contains photos of 11 available styles and outlines construction materials, sizes, pressure and temp ratings, dimensions, max capacities and min flow for actuation (where applicable). OPW-Jordan Corp, 6013 Wiehe Rd, Cincinnati 37.

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MULTI-TURN POTENTIOMETERS—Bulletin AE26, 2 pp. Lists specifications and standard value characteristics of $\frac{7}{8}$-in. dia units for either bushing or servo mount. Dimension drawings are included. International Resistance Co, 401 N Broad St, Philadelphia 8.

Circle 362 on Reader Service Card

INDICATOR LIGHTS—Bulletin 107, 2 pp. Covers physical and electrical specifications of miniature, front-mounting series. Also carries electrical connection diagram and full size outline drawing with mounting hole dimensions. Transistor Electronics Corp, 3357 Republic Ave, Minneapolis 26.

Circle 363 on Reader Service Card

REINFORCED PLASTICS—Bulletin 300-61, 6 pp. Reviews current materials, fabrication techniques and applications. Laminate sizes are given. Swedlow Inc, 6986 Bandini Blvd, Los Angeles 22.

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HOSE FITTINGS—Brochure HM-501, 8 pp. Deals with fittings for service up to a nominal 5000-psi working pressure, 7500-psi proof pressure and 10,000-psi burst pressure. Performance of individual components is discussed, and data on available

continued on page 103

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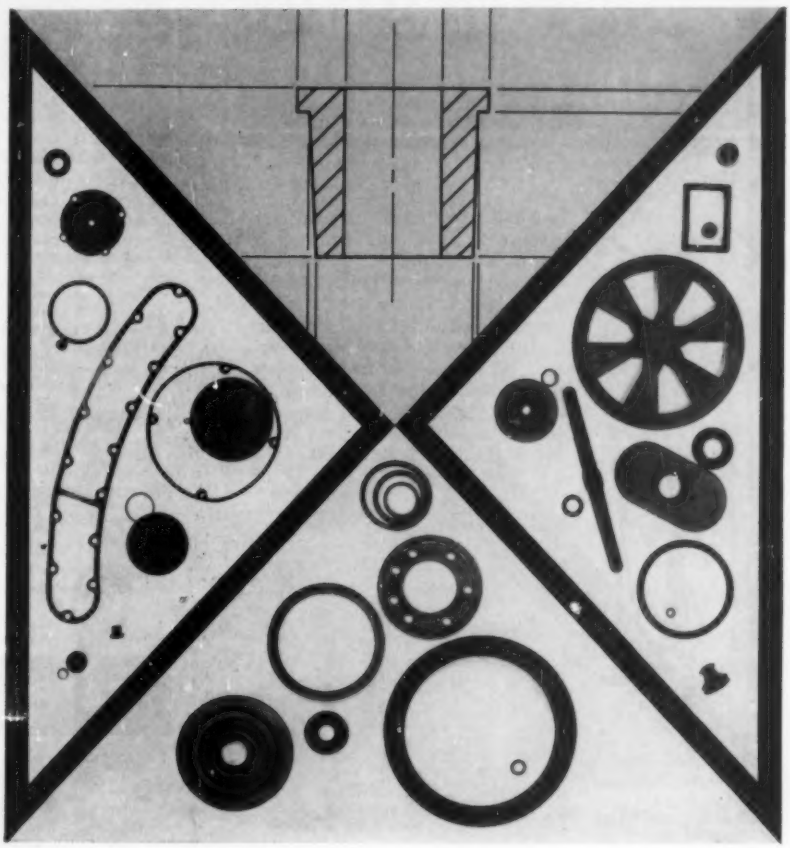

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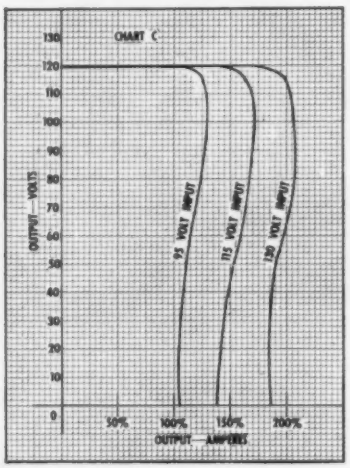

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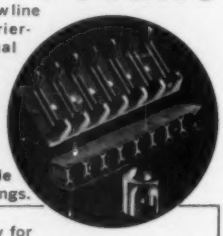

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sizes and materials is supplied. Harrison Mfg Co, 2908 N Naomi St, Burbank, Calif.

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DRAFTING-PEN SET—Catalog sheet, 2 pp. Outlines design features and lists prices and accessories for pen which uses a capillary principle to control ink flow and draws 1000 ft of line on a single filling. Ozalid Div, General Aniline & Film Corp, 515 Corliss Lane, Johnson City, NY.

Circle 366 on Reader Service Card

TESTING AND RESEARCH—Brochure, 24 pp. Traces facilities and types of service rendered in applied research, product development and testing in fields of hydraulics, pneumatics, metallurgy, dynamic and climatic environments, structural dynamics and mechanics. Flexonics Research Laboratories, Bartlett, Ill.

Circle 367 on Reader Service Card

CONTROL-PANEL HARDWARE—Catalog sheets 9001, 4 pp. Design features, prices and dimension drawings are carried for handle assemblies with 2- and 3-point latching systems, latch assembly and door interlocks used for NEMA Type 1 or 12 industrial control enclosures. Gemco Electrical Co, 25685 W Eight Mile, Detroit 40.

Circle 368 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

COMMERCIAL GLASSES—Brochure B-83, 16 pp. Traces mechanical, electrical and optical properties, thermal stress, heat transmission, viscosity, corrosion resistance and thermal expansion of 32 commercial glasses. Contains performance curves and table summarizing application and property data. Corning Glass Works, Corning, NY.

ELECTROLUMINESCENT PANELS—Brochure E-L, 8 pp. Details physical, electrical and color characteristics; life expectancy; energy loss; power factor; and other features of up to 100-sq-in. panels. Performance curves are supplied. Astromatic Div, Controls Co of America, 4218 W Lake St, Chicago 24.

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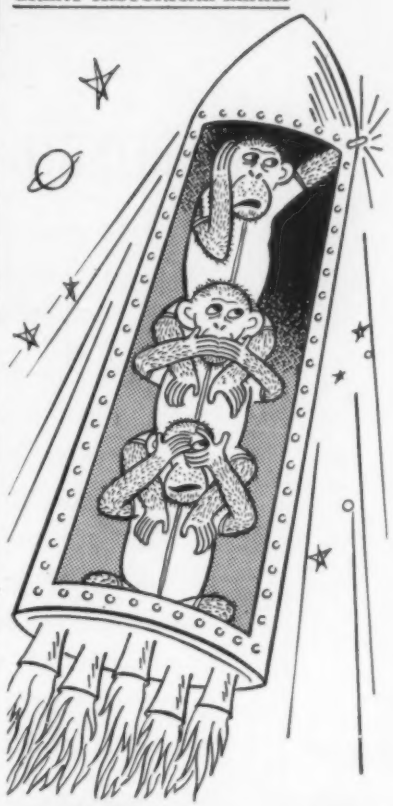

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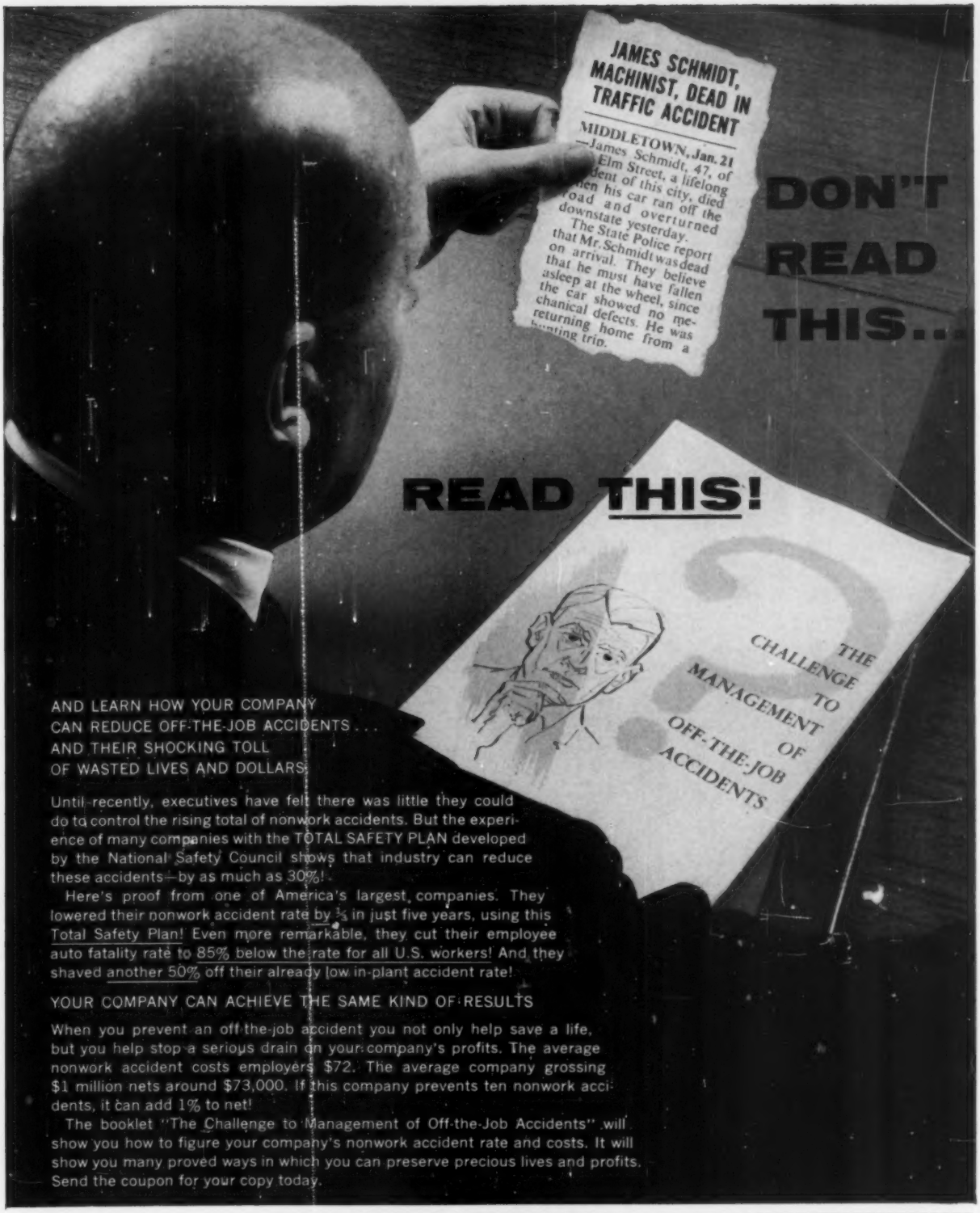
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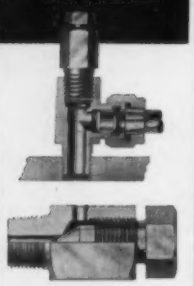

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MOUNTS IN ANY POSITION

ONLY 2 MOVING PARTS

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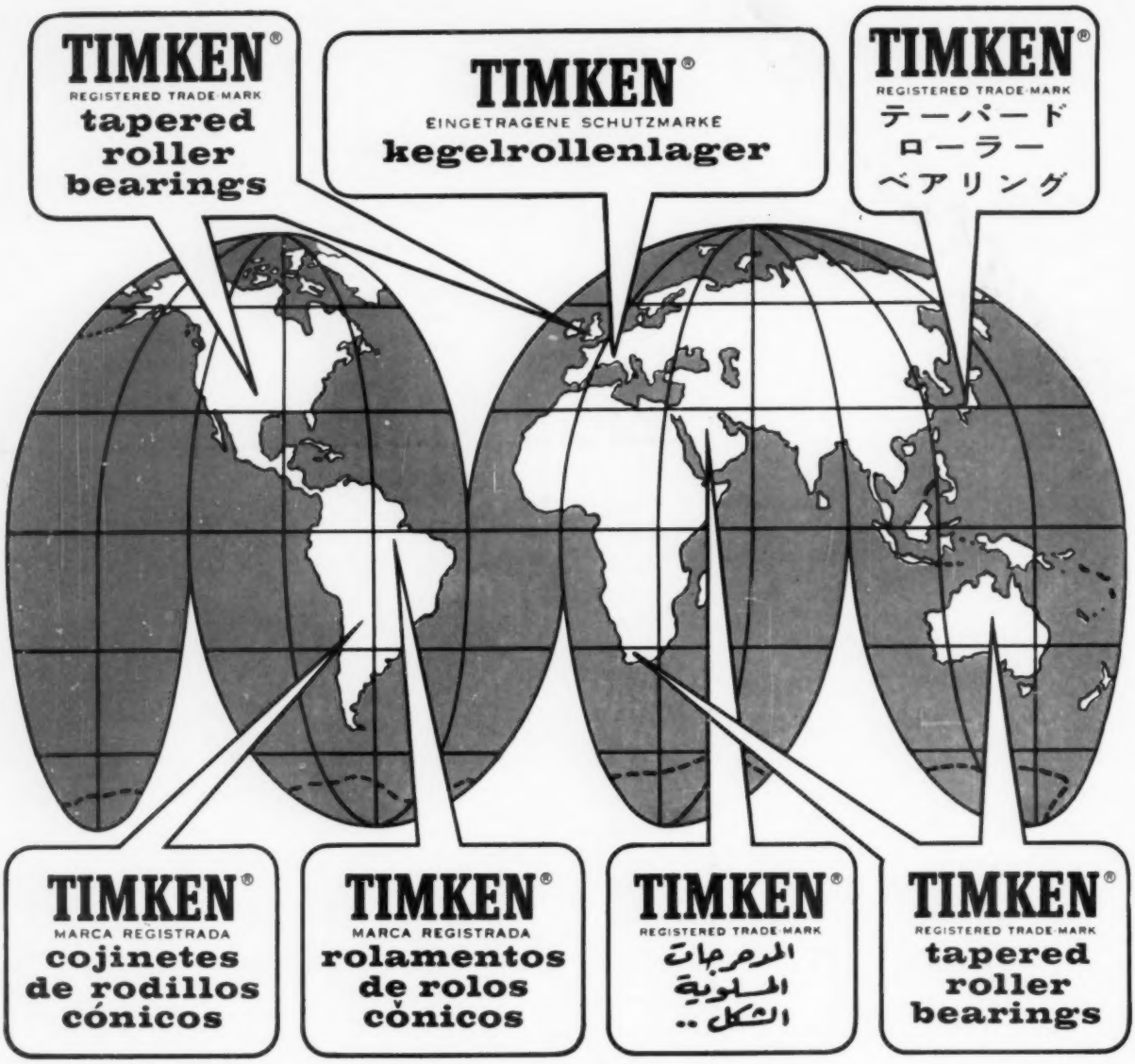

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